

PHYSICS ABSTRACTS

SECTION A
of
SCIENCE ABSTRACTS

SECTION A, PHYSICS
SECTION B, ELECTRICAL ENGINEERING

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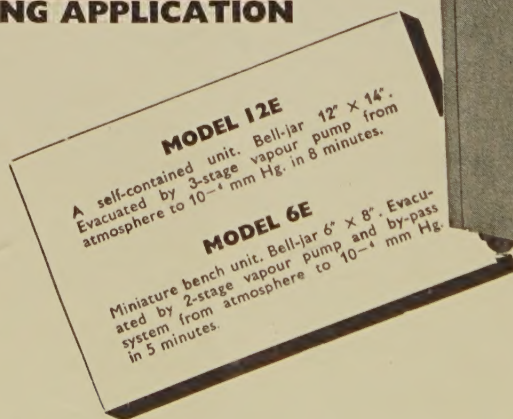
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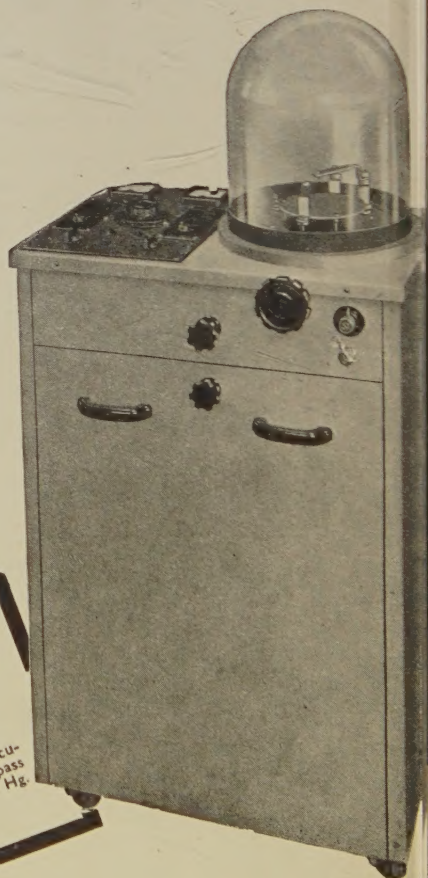


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RELATED SUBJECTS CONTAINED IN SECTION B (ELECTRICAL ENGINEERING ABSTRACTS)

Electrical and magnetic measurements and instruments	Waveguides	Amplifiers
Electronic relays and counters	Photocells	Electroacoustic apparatus
Automatic control mechanisms	Thermionic tubes	Radiocommunication
Applied electrochemistry	Cathode-ray tubes	Mechanical engineering
Lines and networks	X-ray tubes	Illumination
	Oscillators. Pulse circuits	

LIST OF JOURNALS

Notes

- Brit. Commun. and Electronics* *British Communications and Electronics*. Formerly *Communications and Electronics* (*Commun. and Electronics* [London]).
- Commun. and Electronics* [London] *Communications and Electronics*. Title changed to *British Communications and Electronics* [*Brit. Commun. and Electronics*] commencing with the issue dated May, 1955.
- K. Danske Vidensk. Selsk. mat.-fys. Medd.* *Det Kgl. Danske Videnskabernes Selskab, Matematisk-fysiske Meddelelser*. Address changed to Dantes plads 5, Copenhagen V.
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Errata

- Abstr. 3627 (1949), line 2: for GRATCHIANSKAYA read GRATSIANSKAYA.
- Abstr. 72 (1955), line 2: for GINSBURG read GINZBURG.
- Abstr. 1015 (1955), line 4: for $+0.3$ eV read $+0.18$ eV.

Corrections to Articles

Corrections have been published, as shown below, to the articles whose abstract numbers are given. Unless otherwise stated, the volume and page given refer to the journal named in the abstract, i.e. the journal in which the original article was published.

- Abstr. 6564 (1953): 27, No. 1, 180 (Jan., 1955).
- Abstr. 8455 (1953): 26, No. 3, 303 (March, 1955).
- Abstr. 3163 (1954): 27, No. 1, 179 (Jan., 1955).
- Abstr. 7518 (1954): 26, No. 2, 253-4 (Feb., 1955).
- Abstr. 9421 (1954): 26, No. 2, 233 (Feb., 1955).
- Abstr. 149 (1955): 27, No. 1, 180 (Jan., 1955).
- Abstr. 735 (1955): 12, No. 5, 697 (Nov., 1954).
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If no indication of language is given in the abstract, the article may be assumed to be in English. This does not necessarily hold, however, for abstracts reprinted from elsewhere, as indicated at the foot of the abstract.

MATHEMATICS 51

517.532
3381. The general form of the singular solutions of the wave equation. F. FER. *C.R. Acad. Sci. [Paris]* **240**, No. 6, 600-2 (Feb. 7, 1955) In French.

An infinity of singular solutions, in the form of an integral, is deduced, using the Hadamard method of treating the Cauchy problem.

L. S. GODDARD

517.946.5
3382. A string-net analog for the numerical solution of the equations of Laplace and Poisson. P. L. TEA. *J. Franklin Inst.*, **258**, No. 4, 287-304 (Oct., 1954).

Points out that string-nets can be set up to derive the surfaces obtained by Southwell's relaxation method. Solutions found by relaxation and by means of a string-net were compared with the exact solution, for a simple problem; two other problems satisfying the Laplace equation were studied.

N. M. KING

518.2
3383. Table of sine and cosine integrals for arguments from 10 to 100. *Appl. Math. Ser. Nat. Bur. Stand.*, No. 32, 187 pp. (1954).

A supplement for larger arguments, $x = 10(0.01)100$ to decimal places, to tables of $\int_0^x (\cos u/u)du$ and $\int_0^x (\sin u/u)du$, published earlier [*Math. Tables, Nat. Bur. Stand.*, No. 5 (1940)].

G. J. KYNCH

518.2
3384. Table of the gamma function for complex arguments. *Appl. Math. Ser. Nat. Bur. Stand.*, No. 34, 105 pp. (1954).

Tables of $\log_e \Gamma(x + iy)$, $x = 0(0.1)10$, $y = 0(0.1)10$ to 12 decimal places. The introduction includes a complete set of interpolation formulae, giving the accuracy of each procedure for various values of the argument, together with a bibliography of earlier tables.

G. J. KYNCH

518.2
3385. Tables of functions and zeros of functions. *Appl. Math. Ser. Nat. Bur. Stand.*, No. 37, 211 pp. (1954).

This volume, the first of a series, contains tables already published and collected together for convenience, together with reprints of the relevant parts of the original papers in which they appeared. This volume contains 10 groups of tables of functions and 8 of zeros.

Tables of functions include

(1) $H(a, m, x)$ and dH/dx , $x = 1(1)10$, $a = 1(1)10$, $m = 0(1)3$, 7S (S = significant figures, D = no. of decimal places);

(2) $\int_0^x J_0(t)dt$ and $\int_0^x Y_0(t)dt$, $x = 0(0.1)10$, 10D;

(3) $\int_0^x [J_0(t)/t]dt$, $x = 0(0.1)10(1)22$, 10D;

(4) $(x/2)^{-n} J_n(x)$, $x = 0(0.05)10$ ($n = 2, 3$),
 $x = 0(0.05)6.5(0.1)10$ ($n = 4, 5$),
 $x = 0(0.05)1.5(0.1)10$ ($n = 6-8$),
 $x = 0(0.1)10$ ($n = 9-20$);

(5) $\int_1^\infty e^{-xu} u^{-n} du$, $n = 0(1)20$, $x = 0(0.01)2(0.1)10$, 7 to 10D;

(6) Struve functions $L_\nu(x)$ and $H_\nu(x)$, $\nu = 0, -1, -2$, $x = 0(0.1)10$, 7 to 10S;

(7) Fourier coefficients $\int_0^1 x^k \sin n\pi x dx$ and $\int_0^1 x^k \cos n\pi x dx$, $k = 0(1)10$, $n = 1(1)100$, 10D;

(8) $\sin x$ and $\cos x$, $x = 100(1)1000$ radians, 8D;

(9) Radix tables for logarithms to 25D, of $\log n$ and $\log(1 \pm 10^{-n})$, $n = 1(1)14$, 28D;

(10) $x^n/n!$ for series expansions, $x = 1(1)10$, $n = 1(1)80$, 8S.

Tables of zeros:

(1) of $P_n(x)$, $n = 1-16$, 15D, and weight coefficients for the Gauss mechanical quadrature formula;

(2) of first 15 Laguerre polynomials, 12D;

(3) first 5 roots of $J_0(x)Y_0(kx) = J_0(kx)Y_0(x)$, $k = 1.5(0.5)4$, 6S and references;

(4), (5) and (6) first 30 roots of $J_\nu(x)$ and first 7-8 roots of $J'_\nu(x)$ $\nu = \pm \frac{1}{3}, \pm \frac{2}{3}, \pm \frac{4}{3}, \pm \frac{5}{3}$, 10D;

(7) Complex zeros of $Y_0(z)$, $Y_1(z)$, $Y'_1(z)$;

(8) first 10 roots of $\sin z = z$. G. J. KYNCH

518.2 : 519.2

3386. Tables of the error function and its derivative. *Appl. Math. Ser. Nat. Bur. Stand.*, No. 41, 302 pp. (1954).

A reprint of *Tables of probability functions*, vol. I [*Math. Tables, Nat. Bur. Stand.*, No. 8 (1941)], with corrections to three misprints, namely $(2/\pi^{\frac{1}{2}}) \int_0^x e^{-x^2} dx$, $x = 0(0.0001)1(0.001)5.6$ to 5.946, to 10 decimal places, and $(2/\pi^{\frac{1}{2}})e^{-x^2}$, $x = 4(0.1)10$, to 8 significant figures.

G. J. KYNCH

518.42

3387. A new graphical solution of ordinary linear differential equation of the second order. I. OSHIDA. *J. Phys. Soc. Japan*, **10**, No. 3, 228-32 (March, 1955).

A new graphical solution applicable to linear differential equations of second order was presented. This method is simpler in construction but is of higher accuracy than the older methods. Two examples were given and it was shown that the error is very small in practice. The derivative dy/dx , as well as the solution $y(x)$ itself, is obtained simultaneously. Accordingly, this method can be conveniently applied to classical vibrations problems, quantum-mechanical collision problems, eigenvalue problems in one dimension, and so forth.

A.

518.5

3388. An analog computer for nonlinear coordinate transformation. N. L. FRITZ. *Rev. sci. Instrum.*, **26**, No. 1, 23-7 (Jan., 1955).

Transformations in multicomponent analysis frequently are better represented by second-degree simultaneous equations than by the usual linear equations.

For problems requiring repetitive evaluation of a set of equations in which the coefficient terms do not change, an analogue computer can be used to obtain the results both rapidly and accurately. A computer is described which will evaluate three second-degree equations, each of ten terms, as rapidly as an operator can set the input data on the dials, and with an accuracy better than 0.2% of the maximum value. A.

518.5 : 548.735.44

A fast digital computer for Fourier operations. See Abstr. 4199

518.5 : 621.376 : 621.317.79

3389. Two new electronic analog multipliers. M. A. MEYER AND H. W. FULLER. *Rev. sci. Instrum.*, **25**, No. 12, 1166–73 (Dec., 1954).

Describes two new four-quadrant analogue multipliers which have some advantages over other designs which have been reported earlier. A satisfactory balanced modulator which is necessary for both designs is described in some detail. The first multiplier uses a modified double amplitude modulation scheme applying the recent work of Sternberg and

Kaufman on the two-frequency modulation product problem. The test multiplier has a frequency response from d.c. to 30 kc/s for either input. The accuracy is $\pm 0.5\%$ of full scale at full scale output, and $\pm 0.2\%$ of full scale at one-tenth of full-scale output. The d.c. drift stability of the output is $\pm 0.15\%$ of full scale, and the scale factor stability is $\pm 1\%$ of full scale over a period of several hours. The second multiplier uses successive phase modulation and amplitude modulation of a carrier. A description of the method and a discussion of error sources are given. The performance of this multiplier is in general inferior to that of the first. A.

519.2 : 517.942.9

3390. A statistical process for solving the Laplace differential equation with electronic calculators. H. HARMUTH. *Acta phys. Austriaca*, **9**, No. 1, 27–32 (1954) In German.

The method is explained (it is similar to a Monte Carlo method) and an example is given. An extension to Poisson's equation is indicated. Solutions in three dimensions are also considered. L. S. GODDARD

ASTRONOMY . ASTROPHYSICS . GEODESY 52

522.6

3391. The effective quantum efficiency in astronomical spectroscopy. P. E. ARGYLE. *J. Roy. Astron. Soc. Canada*, **49**, No. 1, 19–26 (Jan.–Feb., 1955).

An estimate of the effective quantum efficiency of fast emulsions used in astronomical spectroscopy is made by comparing the actual performance of the Kodak 103 aO emulsion with the calculated performance of an "ideal" emulsion, whose performance is limited only by the signal-to-noise ratio in the starlight itself. It is found that the ideal emulsion would be seven magnitudes faster than the 103 aO. An electronic method of obtaining spectra that shows promise of greater efficiency than photographic methods, at least in certain wavelength regions, is briefly described and some preliminary experimental results are mentioned. A.

522.615

3392. Photoelectric observations of stars with an interference wedge-filter. F. LENOUEL AND J. RING. *C.R. Acad. Sci. [Paris]* **240**, No. 3, 276–8 (Jan. 17, 1955) In French.

Provisional results are given for the wavelength interval, 4000 Å to 6000 Å, which is covered by a wedge-filter 18 cm long. Measures are made at the following positions—H δ , 4200 Å, H γ , H β , 5085 Å and 5460 Å. At each wavelength the band-pass is ~ 70 Å, and the transmission $\sim 80\%$ when the filter is combined with appropriate masking-filters of glass. Spectral types are readily determined from the colour-indices, and with a telescope of 120 cm aperture, stars of 12 mag are still measurable. D. R. BARBER

523.12 : 530.12

3393. On the energy-momentum tensor and the creation of matter in relativistic cosmology. F. A. E. PIRANI. *Proc. Roy. Soc. A*, **228**, 455–62 (March 22, 1955).

It is assumed that the continual creation of matter is accompanied by the creation of entities of zero rest-

mass and negative energy in such a way that 4-momentum is conserved at each creation event. The entities, which are called *gravitinos*, have the properties of Synge's "attractive impulses." The contributions of gravitinos to the energy-momentum tensor give rise to McCrea's zero-point stress and, in addition, to a zero-point energy. An argument of quantum-theoretical character is used to show that the annihilation of matter by gravitinos is relatively unlikely to occur in an expanding universe. It is suggested that the connection with quantum theory can be developed by identifying the gravitino as a neutrino of negative energy. A.

523.162

3394. Polarization of starlight in the region of a filamentary structure of interstellar clouds. A. BEHR AND W. TRIPP. Note in *Naturwissenschaften*, **42**, No. 1, 9 (1955) In German.

Within a filamentary region in the vicinity of the North American and Pelican nebulae it is found that the W zone exhibits areas of plane-polarization whose axes follow closely the direction of individual filaments, maximum values of polarization corresponding to the regions where the filaments are most conspicuous. In the E zone of the region polarization is weak and irregular. D. R. BARBER

523.164

3395. Galactic and localized source observations at 250 megacycles per second. J. D. KRAUS, H. C. KO AND S. MATT. *Astron. J.*, **59**, No. 11, 439–43 (Dec., 1954).

Radio isophotes of the background radiation are shown by a map and the positions of 207 localized sources are presented by a table. About one-quarter of the sources agree in position with those previously reported by Mills or Ryle while the remainder are new. A.

523.165 : 537.591.1
3396. The outline of a theory to explain the origin of cosmic rays. J. HIEDMANN. *C.R. Acad. Sci. [Paris]* **240**, No. 5, 511–13 (Jan. 31, 1955) In French.

Suggests a scheme in which cosmic rays are accelerated by an electromotive force induced in and around our galaxy by the Great Cloud of Magellan. Cosmic-ray energies of up to 10^{15} eV can be explained by this means.

A. J. EGGINTON

523.165 : 537.591.1
3397. A theory to explain the origin of cosmic rays. J. HEIDMANN. *C.R. Acad. Sci. [Paris]* **240**, No. 6, 618–20 (Feb. 7, 1955) In French.

Using the theory introduced in an earlier paper (preceding abstract), it is shown that the most probable energy of cosmic rays is about 1.5 BeV or fairly near the observed value of 1 BeV. The difference in behaviour of cosmic rays with energies above and below the most probable energy can also be explained.

A. J. EGGINTON

523.165 : 537.591.1
Acquisition of cosmic ray energies by electromagnetic induction in galaxies. See Abstr. 3861

523.53
3398. The diffusion of ionized meteor trails in the upper atmosphere. J. S. GREENHOW AND E. L. NEUFELD. *J. atmos. terrest. Phys.*, **6**, No. 2–3, 133–40 (March, 1955).

The variations with height of the durations of radio echoes from ionized meteor trails are discussed. At wavelengths of 8.27 m and 4.35 m echo duration decreases approximately exponentially between altitudes of 80 and 100 km, in the manner predicted by diffusion theory. The diffusion coefficient between these heights varies between 10^4 and 10^5 cm²/sec. These figures are very close to the theoretical estimates of diffusion coefficient, calculated from the rocket panel values of upper atmosphere air densities. A.

523.72
3399. The sun's magnetic field and corpuscular emission. H. W. BABCOCK AND H. D. BABCOCK. Letter in *Nature [London]* **175**, 296 (Feb. 12, 1955).

Analysis of magnetograms obtained with the new solar magnetograph [Abstr. 1962 (1954)], over a two-year period (including the recent sunspot minimum) indicates that (i) there exists on the sun a dipole magnetic component opposite in polarity to that of the earth, and usually limited to heliographic latitudes $> \pm 55$ degrees; (ii) in lower latitudes, bipolar regions appear in association with sunspot structures and obey Hale's polarity law; (iii) unipolar regions unassociated with visible spot-activity are recognizable uniquely on the magnetograms, and appear related to Bartel's *M*-regions. One such region prominent in 1953 had a mean intensity of 0.5 G, and persisted for > 9 months; (iv) objective evidence is found for magnetic activity associated with a variety of chromospheric, and coronal phenomena, and perhaps also *M*-regions. A tentative model for corpuscular ejection from turbulent regions of the solar photosphere where the mean magnetic field intensity exceeds 0.5 G (with max. ~ 500 G) is briefly outlined.

D. R. BARBER

523.72 : 537.533.9
3400. Nonlinear theory of space-charge wave in moving, interacting electron beams with application to solar radio noise. H. K. SEN. *Phys. Rev.*, **97**, No. 4, 849–55 (Feb. 15, 1955).

A consideration of the complete equations of interaction (without the linear approximation) of two moving electron beams of given densities (with sufficient numbers of ions to make the charges macroscopically neutral) shows that propagation of steady-state space-charge waves is possible in such a medium. The period of the space-charge wave is a function of its amplitude and phase velocity. For small amplitudes the oscillation is simple harmonic, and the characteristic dispersion equation of the first order theory is obtained. For a given phase velocity of the wave, the oscillation becomes increasingly anharmonic with increase of amplitude. Beyond a particular value of the amplitude (which is a function of the phase velocity of the wave), the waveform of the oscillation becomes discontinuous. The above theory is applied to estimate the relative intensity of the second harmonic component in solar radio outbursts recently discovered by Australian workers. A theoretical analysis based on the antenna theory of electromagnetic radiation from oscillating plasma gives a radio flux of the order of magnitude of that observed.

A.

523.746
3401. Magnetic intensification and the sunspot curve of growth. J. W. WARWICK. *Z. Astrophys.*, **35**, No. 4, 245–51 (1955).

A parameter is proposed to measure the intensification effect of a longitudinal magnetic field on an anomalous Zeeman pattern. The parameter is justified in terms of a semi-quantitative evaluation of equivalent widths in blending components. This parameter predicts rather large differential intensification effects from line to line in the sunspot data obtained at Potsdam (ten Bruggencate and von Klüber). Since the data show no such effects, it is concluded that the sunspot spectra give evidence for a real turbulence effect, instead of a "pseudo-Doppler" effect. The turbulent velocities are of the order of 2 km/sec. A.

523.76 : 538.3
3402. Solar electrodynamics. J. W. DUNGEY. *J. atmos. terrest. Phys.*, **6**, No. 2–3, 88–90 (March, 1955).

It is suggested that confusion in solar electrodynamics arises from the use of causal relationships borrowed from laboratory electrodynamics. A concept of "causality" is introduced which depends on the fundamental equations used, so that the causal relationships must be changed when approximations are made. This concept is used to discuss the reduction in conductivity by a magnetic field and the effect of a polarization electric field.

A.

523.83
3403. An attempt to determine objective prism radial velocities. C. SCHALÉN. *Ark. Astron.*, **1**, Paper 37, 545–60 + i p. figs. (1954).

Using a direct-vision compound prism of the type suggested and used by Fehrenbach the reversion method of determining objective prism radial velocities has been tested by measuring $H\gamma$ and $H\delta$ in *B-F* stars

of known radial velocity. The dispersion used amounts to 113 Å/mm at H γ -H δ . There is a fairly good relation between the observed radial velocity and the displacement measured on the plate, if precautions are taken to measure only plates of the highest quality and stars with not too hazy and broad or faint lines. From two to four plates have been measured of each region. The mean error of a determination of a radial velocity from measurements of both H γ and H δ amounts to about 6 km/sec. If, say, 8 plates are measured of each region a mean error of 3-4 km/sec could probably be expected. A.

523.852.22 : 523.872

3404. On the measured relative intensities of lines of O III and H β in the spectra of planetary nebulae. H. ANDRILLAT. *C.R. Acad. Sci. [Paris]* **240**, No. 5, 491-3 (Jan. 31, 1955) In French.

This note points out that a considerable difference exists between the author's measurements and the results of Liller and Aller. A comparison of the methods used by each observer is made and the suggestion is that the difference is due to the observations being in one case over an extended area, whilst in the other a small central area is used.

E. G. MARTIN

523.877 : 539.172.13

3405. Nuclear reactions in stars. II. Protons on light nuclei. E. E. SALPETER. *Phys. Rev.*, **97**, No. 5, 1237-44 (March 1, 1955).

For Pt I, see Abstr. 588 (1953). The rates are calculated for thermonuclear reactions involving the collision of a proton with various light nuclei. These

calculations are based directly on low-energy experiments for deuterium, Li, Be and B, partly on experiments for O¹⁶, and purely on theoretical estimates for the other isotopes of O, F, Ne and Na. Temperatures are calculated at which D, Li, Be and B are effectively destroyed by these reactions, both in the interior of young and cool stars which are still contracting gravitationally and in the outer layers of main sequence stars. It is shown that in the interior of even a hot main sequence star only O¹⁸ and F¹⁹ (and possibly O¹⁷) are destroyed of all the isotopes heavier than nitrogen. A.

529.781 : 538.566.2

3406. World-wide frequency and time comparisons by means of radio transmissions. J. A. PIERCE, H. T. MITCHELL AND L. ESSEN. Letter in *Nature [London]* **174**, 922 (Nov. 13, 1954).

The standard frequency transmissions at between 2.5 and 25 Mc/s can be subject to transmission errors of 2 in 10⁷ due to Doppler effects as the ionospheric reflecting layers move. A transmission on 60 kc/s from Rugby has been used. The reflecting layer for such low-frequency transmissions is relatively stable. These signals can be used in the U.K. to an accuracy of 1 in 10⁹. These signals and those of the 16 kc/s GBR (which is controlled by the same standard) have been received at Harvard, U.S.A. Photographic records show that the path is free from short-period fluctuations, but there are slow diurnal movements of the reflecting layer. The use of the low-frequency transmission makes possible a world-wide frequency standardization to 1 in 10⁹. W. T. BLACKBAND

PHYSICS 53

FUNDAMENTALS 530.1

530.1

3407. Symmetry of physical laws. I. Symmetry in space-time and balance theorems. S. WATANABE. *Rev. mod. Phys.*, **27**, No. 1, 26-39 (Jan., 1955).

In default of the theorem of "detailed balance": $P_{ij} = P_{ji}$, with regard to elementary transition probabilities, several "balance" theorems are introduced and proved on the basis of symmetry of physical laws in space-time. (1) First theorem of "averaged balance": $\bar{P}_{ij} = \bar{P}_{ji}$ can be established by averaging over quantities of "minus class." The "minus" quantities are tabulated. (2) The so-called "detailed balance of collisions" in classical physics is a special case of Theorem 1. (3) Heitler-Coester's theorem of "semi-detailed balance" is also a special case of Theorem 1. (4) Second theorem of "averaged balance": $\bar{P}_{ij} = \bar{P}_{ji}$ can be established by averaging over quantities with $\rho_R = -1$. The quantities with $\rho_R = -1$ are tabulated. (5) Theorem of "cyclic balance": In classical physics, a chain of transitions $i \rightarrow j \rightarrow k \rightarrow \dots \rightarrow i$ repeats itself cyclically. (6) Theorem of "long-range balance": The time average of transition probability from i to j is equal to the time average of transition probability from j to i . Theorems 1, 2 and 3 are direct consequences of invertibility (covariance for space-and-

time inversion). Theorem 4 is a consequence of reversibility (covariance for time reversal). Theorems 5 and 6 are connected with ergodicity of Markoff's chains. This ergodicity is proved by the condition of bilateral normalization of transition probabilities: $\Sigma_j P_{ij} = 1$, $\Sigma_i P_{ij} = 1$. This bilateral normalization in turn can be derived from either reversibility or invertibility. The limits of validity of all these balance theorems in actual applications are carefully examined in the text. A.

530.1

3408. Symmetry of physical laws. II. Q-Number theory of space-time inversions and charge conjugation. S. WATANABE. *Rev. mod. Phys.*, **27**, No. 1, 40-76 (Jan., 1955).

Symmetry properties of physical laws with respect to space-inversion, time-reversal and charge-conjugation are investigated in detail in the framework of the quantized field theory. In most cases, the requirements of invariance for these transformations are automatically satisfied; in a few other cases they can impose certain conditions on the ways in which different types of interaction are to be mixed. The ideas of space-parity, charge-parity and superselection rules are coherently derived from the general formulation of field theory. A.

530.12
3409. Some remarks on Jordan's projective relativity. H. NARIAL. *Sci. Rep. Tôhoku Univ. First Ser.*, **37**, No. 4, 423-30 (1953).

Starting from a generalized form of Jordan's field equations in his projective relativity, two special cosmological models are discussed, together with Heckmann's solution corresponding to Schwarzschild's in general relativity. A.

530.12
3410. On the wave theory of light in general relativity. II. Light as the electromagnetic wave. Y. UENO. *Progr. theor. Phys.*, **12**, No. 4, 461-80 (Oct., 1954).

In Pt I [Abstr. 5265 (1954)] a wave-theoretical method of treating the path of light in general relativity was developed. In this paper the wave character of light in a curved space-time is further investigated from the standpoint of electromagnetic optics by using the generalized Maxwell equation in a curved space-time. The main problem treated in this paper is that of a spherical light wave in static spherically symmetric space-times, and the properties of this wave are clarified by solving the wave equation of light. The wave character of light radiated from the sun is investigated by means of the results obtained by solving the generalized Maxwell equation in Schwarzschild space-time. A.

530.12
3411. Motion of a mass which annihilates its own gravitational field. C. GRAEF FERNÁNDEZ. *Rev. Mexicana Fis.*, **3**, No. 4, 253-67 (Oct., 1954) In Spanish.

It is shown that, on Birkhoff's theory of gravitation, it is possible to move a point mass relative to a test particle in such a way that the test particle would experience no gravitational field. R. A. NEWING

530.12
3412. The propagation of light rays in moving media. N. L. BALAZS. Letter in *J. Opt. Soc. Amer.*, **45**, No. 1, 63-4 (Jan., 1955).

The general relativity theory is employed to discuss the propagation of light in a medium moving, with any velocity v , in presence of a gravitational field. The results obtained are general, though the final expression is evaluated only to the first order in v/c . P. M. DAVIDSON

530.12 : 530.145 : 523.11
3413. Photonic action in gravitation and cosmology. H. FABRE. *C.R. Acad. Sci [Paris]* **240**, No. 2, 158-60 (Jan. 10, 1955) In French.

Field equations in the absence of matter are assumed to be of the form $G_{\alpha\beta} + \lambda g_{\alpha\beta} = \lambda(W_{\alpha\beta} - \frac{1}{2}g_{\alpha\beta}W)$ and to reduce to a wave equation for a photon of mass m as a first approximation, $2\pi cm/h$ and $\lambda^{1/2}$ being of the same order of magnitude. Application to model universes is discussed. R. A. NEWING

530.145
3414. A causal interpretation of the Pauli equation (A). D. BOHM, R. SCHILLER AND J. TIOMNO. *Nuovo Cimento Suppl. (Ser. 10)* **1**, No. 1, 48-66 (1955).

The hydrodynamical model of causal motion proposed by Madelung in 1926 is generalized. This model has been extended by the postulate that there

is a stable particle-like inhomogeneity in the fluid that moves with the local stream velocity [Abstr. 10778 (1954)]. In the Pauli equation, the wave-function ϕ is a spinor and two additional quantities must be interpreted. These are determined by assuming an intrinsic (spin) angular momentum in the fluid, and the kinematics of this are formulated. G. E. BROWN

530.145
3415. A causal interpretation of the Pauli equation (B). D. BOHM AND R. SCHILLER. *Nuovo Cimento Suppl. (Ser. 10)* **1**, No. 1, 67-91 (1955).

A model more general than that of the preceding abstract is given, and the Pauli equation results as a special case in which the angular momentum points along a particular axis at a given time, and the torques are such that this condition is maintained. The model is illustrated in terms of a stationary state of an electron in an atom. It is shown how a continuous distribution of angular momentum can lead to discrete (quantized) values for the fluid as a whole. G. E. BROWN

530.145
3416. Configuration space representation for non-linear fields. P. KRISTENSEN. *K. Danske Vidensk. Selsk., mat.-fys. Medd.*, **28**, No. 12, 53 pp. (1954).

A reformulation of quantum field theory is given, in which any state of the system considered is represented by a functional depending on external sources. The variational derivatives of this functional provide a generalization of the Fock representation in configuration space to the case of non-linear fields. The representing amplitudes can be expressed entirely in terms of matrix elements of time-ordered products of field operators and possess several simple properties which are independent of the magnitude of the coupling constant. It is shown that these amplitudes satisfy homogeneous equations of motion which can be derived in a simple manner. The equations of the Bethe-Salpeter type following herefrom become identical with those following from Schwinger's theory of Green's functions. This representation has many properties in common with that given by Freese. A.

530.145
3417. Classical motion of nucleons in a scalar field. G. SZAMOSI AND G. MARX. *Ann. Phys. [Leipzig]* **15**, No. 3-4, 182-5 (1955) In German.

In a purely attractive field, a repulsion enters when the absolute value of the potential energy is greater than the rest-energy. G. E. BROWN

530.145
3418. Diffraction by a time-like three-dimensional aperture. O. COSTA DE BEAUREGARD. *C.R. Acad. Sci. [Paris]* **240**, No. 2, 160-2 (Jan. 10, 1955) In French.

From formulae of a preceding work [Abstr. 1519 (1955)] more precise arguments are given, compatible with those of Moshinsky. G. E. BROWN

530.145
3419. Variable mass equations. J. E. MEGGITT. *Phys. Rev.*, **97**, No. 4, 1126-31 (Feb. 15, 1955).

Isotopic spin-space is generalized. The equations of field theory then describe systems of interacting particles as in ordinary isotopic spin-theory, but the

particles and their interactions are more complex. The different systems which arise from different generalizations are systematically discussed. A.

530.145

3420. Classical field theory in the Hamilton-Jacobi formalism. H. FREISTADT. *Phys. Rev.*, **97**, No. 4, 1158-61 (Feb. 15, 1955).

A Hamilton-Jacobi formalism of classical relativistic field theory is developed. Both "time-independent" and "time-dependent" formulations are given, and the relation between them is discussed. In the former, the constants of the motion are identified with the "new" field variables, whereas in the latter they are the values of the fields on a suitable space-like surface. The explicit introduction of a Hamiltonian density is avoided. As an illustration of the respective procedures, the classical Dirac and Klein-Gordon free fields are solved explicitly. A perturbation method is formulated for the case of fields in interaction. The metric tensor is not treated as a field quantity. A.

530.145

3421. On the β -formalism of Kemmer and its quantization on the basis of Schwinger's variational principle. W. HANUS. *Acta phys. Polon.*, **13**, No. 4, 275-89 (1954).

The β -formalism of Kemmer and its canonical quantization is deduced in a fully relativistic form on the basis of the quantum dynamical variational principle of Schwinger. A detailed investigation of the problem of constraints is given. In spite of the special type of constraints inherent in Kemmer's formalism and a somewhat symbolic character of the division into dynamically independent and dependent field components, the results are quite identical with those of the original Kemmer formulation. The canonical commutation relations for independent, dependent and total field variables (the last being sums of the two preceding) are obtained. Some precautions are necessary (in the case of first order field equations treated here), in consequence of the mutual dependence of the field variables and their canonical conjugates. The comparison of the canonical commutation relations obtained in this way with those of Kemmer and with the relativistic form of the commutation relations given by Pauli shows their full conformity and equivalence. It is also shown that the Duffin-Kemmer matrices β_μ and the Dirac matrices γ_μ are the only possible Hermitian operators with eigenvalues 0, ± 1 (or ± 1) leading to the field equations of the Dirac type. A.

530.145

3422. On the time reversal in the quantized field theory. H. UMEZAWA, S. KAMEFUCHI AND S. TANAKA. *Progr. theor. Phys.*, **12**, No. 3, 383-400 (Sept., 1954).

The time reversal transformation is so defined as to preserve the canonical formalism of the theory. It is found that there are two kinds of such transformations, which are shown to correspond to the so-called Pauli and Wigner transformations. The transformation properties of physical quantities under these transformations are examined and the physical meanings of time reversal are clarified. The authors investigate whether the invariance requirement under time reversal really imposes restrictions on the form of

interaction Hamiltonian and the otherwise undetermined phase factors of the coupling constants of the Fermi and Yang-Tiomno interactions. The connection between the generalized time reversal transformation and the concept of the family of elementary particles is studied. In the appendix the transformation is further applied to the Pais theory of baryon-meson-photon system. A.

530.145

3423. Proper-time electron formalism. W. C. DAVIDON. *Phys. Rev.*, **97**, No. 4, 1131-8 (Feb. 15, 1955).

A classical and first-quantized formalism is presented which gives a complete description of electrons in a given electromagnetic field, including real and virtual pair processes. The Feynman viewpoint of electrons propagating through space-time is adopted throughout. Interactions between electrons are considered only in the classical theory, and a non-local interaction is assumed to make all effects finite. Consideration of interactions in the quantized theory is reserved to field quantization, presented in a following paper (abstract following). The calculation of transition probabilities gives the results of hole theory as interpreted by Feynman. A.

530.145

3424. Proper-time quantum electrodynamics. W. C. DAVIDON. *Phys. Rev.*, **97**, No. 4, 1139-44 (Feb. 15, 1955).

The electromagnetic field is included in the proper-time formalism and quantized. All interaction and radiation effects except for vacuum polarization follow directly from the coupling of the quantized photon field to the first quantized electron. The non-local interaction makes the terms in the perturbation expansion finite. The many-electron theory is presented. A suitable interpretation of it permits the evaluation of vacuum polarization effects, preserving gauge invariance, and resulting in a finite charge renormalization. A.

530.145

3425. A note concerning the quantization of spinor fields. Y. TAKAHASHI. *Nuovo Cimento (Ser. 10)* **1**, No. 3, 414-26 (March, 1955).

Jauch's paper [Abstr. 6266 (1954)] is re-examined by use of the usual quantization formalisms. Schwinger's action principle can give the commutation relations suggested by Jauch, if appropriate canonical independent variables are chosen, different from the variational independent variables. Quantization in the interaction representation is also discussed. The interaction between Jauch's field and the electromagnetic field is considered. A.

530.145

3426. Supplementary conditions in quantized linear systems. J. K. PERCUS. *Phys. Rev.*, **97**, No. 5, 1406-13 (March 1, 1955).

A scalar product formalism is presented for the commutation relations and quadratic constants of the motion of a linear system. The modification of commutation relations necessitated by a supplementary operator condition is obtained by means of a projection operation, for which several computational methods are developed; some simple applications are discussed.

The foregoing analysis is extended to a sequence of supplementary conditions; it is then applied to quantization of the integral-spin real-meson field. A.

530.145

3427. Quantization of non-linear electrodynamics. M. SUFFCZYŃSKI. *Acta phys. Polon.*, **13**, No. 4, 291–9 (1954).

Non-linear electrodynamics of Born and Infeld is put into Hamiltonian form by Dirac's method [Abstr. 4088 (1951)]. A.

530.145

3428. Many-body problem in quantum field theory. II. K. NISHIJIMA. *Progr. theor. Phys.*, **12**, No. 3, 279–310 (Sept., 1954).

For previous part, see Abstr. 5305 (1954). In view of the fact that really observable particles are not bare but dressed with their self field, procedures for rigorous treatment of dressed particles are presented. For this purpose, the Green function formalism by Schwinger and covariant equations by Bethe and Salpeter are useful. Relations among various covariant formulations are first discussed. Then the normalization of Bethe-Salpeter wave-functions and the expression of expectation values of given observables in terms of Bethe-Salpeter wave-functions are investigated. Finally the differences of treatment between dressed and bare particles are shown in connection with the scattering problems. A.

530.145

3429. On the conservation of heavy particles. O. HARA, T. MARUMORI, Y. OHNUKI AND H. SHIMODAIRA. Letter in *Progr. theor. Phys.*, **10**, 114–15 (July, 1953).

When the authors' theory [Abstr. 1505 (1955)] is extended to a non-local spinor field there appears, besides the spin and mass observables, a scalar observable with eigenvalues ± 1 corresponding to the 2 families of particles: nucleons and leptons, and related to the "mesic charge" (1 or 0). Conservation of mesic current then corresponds to the conservation of heavy particles. W. J. SWIATECKI

530.145

3430. Causal behaviour of field theories with non-localizable interactions. M. E. EBEL. K. *Danske Vidensk. Selsk., mat.-fys. Medd.*, **29**, No. 2, 30 pp. (1954).

The causal behaviour of field theories with non-localizable interactions of the Kristensen-Møller type is discussed in the perturbation approximation, with particular attention to interactions involving only particles with time-lag momentum vectors. Causal behaviour is understood to imply that all observable particles of positive energy are propagated at a velocity less than the velocity of light. It is shown that the causal behaviour of the non-local interaction theories is determined both by the location of the singularities of the propagation function, and by the continuity of the various derivatives of the form function. It is further demonstrated that, by choosing these derivatives to be continuous in sufficiently high orders, the probability of observing signals propagating with a velocity greater than that of light may be made to decrease more rapidly than any arbitrary inverse power of the distance between the points at which the signal is observed. The relation of this work to other treatments of causality is discussed. A.

443

530.145

3431. Renormalization in the covariant treatment of pion-nucleon scattering. S. CHIBA. *Progr. theor. Phys.*, **12**, No. 4, 481–93 (Oct., 1954).

The problem of renormalization for pion-nucleon scattering is treated in Bethe-Salpeter formalism. A method of subtracting divergencies, especially overlapping divergencies which appear in the solution of an integral equation, is proposed and it is shown that the Salam prescriptions for the subtraction of overlapping divergencies can be achieved in a closed form. Finally, the Green function for the $T = \frac{1}{2}$ state is obtained in a form free from all divergencies. A.

530.145

3432. On the renormalization in the Tamm-Dancoff approximation for one-nucleon problem. I. A covariant generalization of the Tamm-Dancoff method. K. ITABASHI. *Progr. theor. Phys.*, **12**, No. 4, 494–502 (Oct., 1954).

To carry out consistent subtraction of divergencies in the Tamm-Dancoff method, a covariant formalism is proposed for the one-nucleon problem. That is, neglecting all the nucleon closed loops and paying attention to the "development of events along a nucleon line" rather than the "time-like development of events," the simultaneous integral equations for the Feynman kernels which can be regarded as a covariant generalization of T.D. equations are derived. The meaning of the word "meson number" in this theory is also generalized, though it agrees with the usual one when the nucleon pairs are entirely neglected. A.

530.145

3433. Mass spectrum of elementary particles. II. H. ENATSU. *Progr. theor. Phys.*, **12**, No. 3, 363–79 (Sept., 1954).

For Pt I, see Abstr. 8929 (1954). First, the eigenvalue problem of the mass of a Dirac particle is discussed; the mass eigenvalues of the Dirac particle which interacts with itself through scalar photon fields are estimated by a method similar to that developed in the case of a deuteron for a Yukawa well. Secondly, the ambiguities which appear in the calculation of the nucleon self-energy caused by scalar mesons with vector coupling are discussed. It is shown that, in spite of the ambiguities, a fermion ($\sim 2350 m_e$) and a scalar cohesive meson ($\sim 1100 m_e$) may be assumed to get convergence of the nucleon self-energy due to π -mesons. A brief survey of the model of heavy particles which seems to be qualitatively consistent with the recent experimental results, is also given. A.

530.145

3434. The static model of the nucleon. L. TRLIFAJ. *Czech. J. Phys.*, **4**, No. 4, 395–406 (Nov., 1954).

The magnetic moments of the proton and neutron are calculated. It is assumed that both particles are systems composed of the core, nucleon and a cloud of electrically charged mesons. The numerical results are in qualitative agreement with experiment. A.

530.145

3435. Remarks on the theory of fusion. G. A. SOKOLIK. *Zh. éksp. teor. Fiz.*, **28**, No. 1, 13–16 (1955) In Russian.

A generalization of the theory of fusion of de Broglie (in which particles of higher spin are built up

from particles with spin $1/2$) is given. If two equations are given corresponding to Lorentz groups τ_1 and τ_2 , then the equation corresponding to $(\tau_1 \times \tau_2)$ can be found.

G. E. BROWN

530.145

3436. In connection with the article of V. I. Karpman "On the question of a connection between the theory of regularization and theories of particles with arbitrary spin." YU. A. YAPPA. Letter in *Zh. éksper. teor. Fiz.*, **28**, No. 1, 123-4 (1955) In Russian.

Karpman's criticism [Abstr. 7444 (1953)] of a work by the present author [Abstr. 3082 (1954)] arose from a misunderstanding, noted here. Construction of commutation relations for a field with a spectrum of masses is discussed.

G. E. BROWN

530.145

3437. The wave-function u and the associated fluid in the theory of the double solution of M. Louis de Broglie. J.-L. DESTOUCHES. *J. Phys. Radium*, **16**, No. 2, 81-5 (Feb., 1955) In French.

A hydrodynamical picture is proposed as an aid in the development of de Broglie's theory of the pilot wave.

P. T. LANDSBERG

530.145

3438. On the compatibility of certain hypotheses in M. Louis de Broglie's theory of the double solution. J.-L. DESTOUCHES. *J. Phys. Radium*, **16**, No. 2, 86-91 (Feb., 1955) In French.

Six conditions which have to be imposed on the waves which occur in this theory are discussed, and partial answers are given to the question as to their compatibility.

P. T. LANDSBERG

530.145

3439. Particles with spin two. A. DA SILVEIRA. *Phys. Rev.*, **97**, No. 4, 1144 (Feb. 15, 1955).

The possibility of obtaining an equation for particles with spin 2 without the introduction of an additional field is considered. The equation and the supplementary conditions are reduced to those proposed by Pauli and Fierz for the free particle.

A.

530.145

3440. Corrigenda: Radiative corrections to the anomalous magnetic moment of the nucleon in pseudoscalar meson theory. K. NAKABAYASHI, I. SATO AND T. AKIBA. Letter in *Progr. theor. Phys.*, **12**, No. 2, 250-2 (Aug., 1954).

See Abstr. 8512 (1951). Also a detailed discussion of the effect on the anomalous moment of the modified meson propagator ΔF^* .

W. J. SWIATECKI

530.145

3441. Kinematical investigations of meson-nucleon reactions. S. HAYAKAWA, M. KAWAGUCHI AND S. MINAMI. *Progr. theor. Phys.*, **12**, No. 3, 355-62 (Sept., 1954).

The angular distributions and the polarizations of recoil nucleons for meson-nucleon scattering as well as for photomeson production are studied from the kinematical point of view. As in the case of meson-nucleon scattering [see Abstr. 552 (1955)], there exists a simple symmetry property also in photomeson production. The angular distribution is invariant

under the simultaneous interchange of the reaction amplitudes of electric and magnetic radiations with the same multipole order and the same total angular momentum. This interchange upsets the sense of the polarization of recoil nucleons. For practical purposes the tables of the angular distributions and the polarizations are given for J 's up to $3/2$.

A.

530.145

3442. On nuclear force for $^3S_1 + ^3D_1$ state. M. MATSUMOTO AND W. WATARI. *Progr. theor. Phys.*, **12**, No. 4, 503-20 (Oct., 1954).

Deuteron problem and 90 MeV n - p scattering are discussed according to the Taketani prescription. L-shaped potentials are used for the outside potentials, which are nearly equivalent to the meson theoretical potentials. In the inside region phenomenological potentials are used which are composed of a hard core surrounded by square well so as to give the deuteron binding energy correctly. The depths of these inside central and tensor square-well potentials are varied extensively as two parameters, and effects of these variations on the electric quadrupole moment and D -state deuteron probability, triplet effective range of neutron-proton scattering and 90 MeV neutron-proton scattering phase shifts are examined. The results are summarized in various graphs and tables. The depth of the inside central potential does not affect the deuteron physical quantities, which, however, depend on the depth of the inside tensor force. Asymptotic forms of the wave-functions of the neutron-proton system at high energy are mainly determined by the depth of the inside central potential, if the sign of the inside tensor potential is negative. On the other hand, if the inside tensor potential is positive and higher than about 80 MeV the high-energy data depend strongly on both inside parameters. The " D -wave" of the deuteron has one node when the height of the inside tensor potential is larger than about 80 MeV. It is also found that the calculated value of the total cross-section of high-energy n - p scattering is reduced by introducing a hard core, and can be fitted to the experimental values without violating the angular distribution.

A.

530.145

3443. Phenomenological analysis of the meson theory of nuclear force. S. OTSUKI AND S. FUJII. *Progr. theor. Phys.*, **12**, No. 4, 521-36 (Oct., 1954).

Taking into account new development of meson theory of nuclear force both from the field-theoretical and the phenomenological point of view, p - p scattering up to 100 MeV is analysed. Adopting the pseudoscalar meson theoretical potential in the singlet states and subtracting their effect from the experimental data, magnitudes of the central and tensor potential in the triplet odd state are obtained. This analysis shows that the central potential must be very weak and that the tensor potential is not so strong as potentials of the other states. These features also favour to n - p scattering. The meson theoretical potentials of this state are very similar to this phenomenological one and consequently it is concluded that no corrections are requisite that alter the characteristics of the meson theoretical potential of the triplet odd state. The properties of meson

theoretical potentials of the other states are also discussed. A.

530.145

3444. Notes on the theory of intermediate coupling. M. JEAN. *J. Phys. Radium*, **16**, No. 1, 75-7 (Jan., 1955) In French.

See Abstr. 2426 (1955). An alternative treatment is given, convenient when the angular momentum of the system (bare nucleon + meson cloud) exceeds $\frac{1}{2}$.

W. J. SWIATECKI

530.145

3445. Completeness of stationary scattering states. I. N. G. VAN KAMPEN. *Physica*, **21**, No. 2, 127-36 (Feb., 1955).

The scattering phase $\eta(k)$, as a function of the wave-number k , uniquely determines the stationary scattering states outside the scatterer. The problem is to find which properties of $\eta(k)$ entail the completeness of the set of these stationary states. In this paper, sufficient conditions of a rather general character are derived. In particular it is shown that the existence of an analytic continuation of the S -matrix is not a necessary condition. A.

530.145

3446. Amplitudes in nucleon-nucleon scattering. G. BREIT AND M. H. HULL, JR. *Phys. Rev.*, **97**, No. 4, 1047-50 (Feb. 15, 1955).

When scattering anomalies involving many phase shifts are to be studied, it appears desirable to treat the amplitudes directly before combining them into differential cross-sections. Amplitudes suitable for the study of elastic collisions of charged and uncharged Fermi-Dirac particles of spin $\frac{1}{2}$, taking account of possible identity are, therefore, given below, in forms convenient for computation. The case of coupling between states of the same total but different orbital angular momentum is not discussed. Formulae using the spin functions usually denoted by χ_m are supplemented by forms based on spin functions which transform like the components of an ordinary space vector, the latter allowing more compact expressions in some cases. A.

530.145

3447. Polarization and amplitudes in nucleon-nucleon scattering. G. BREIT, J. B. EHRLMAN AND M. H. HULL, JR. *Phys. Rev.*, **97**, No. 4, 1051-9 (Feb. 15, 1955).

The effect of coupling of states of the same J but different L on the nucleon-nucleon scattering amplitudes is investigated. Formulae for the polarization of nucleons in double scattering experiments are presented in a form suitable for numerical computation. In the derivation, special attention is given to the scattering of identical particles, and it is proved that a double scattering experiment involving identical nucleons does not require the consideration of a wave-function antisymmetrized in all three particles. The effect of the coupling on polarization is also discussed. In particular, it turns out that the non-diagonal elements of the coupling matrix give a contribution to the polarization in which the highest order spherical harmonic drops out. A.

530.145

3448. Polarization in scattering by complex nuclei. S. TAMOR. *Phys. Rev.*, **97**, No. 4, 1077-83 (Feb. 15, 1955).

Polarization effects in the elastic scattering of high-energy nucleons by complex nuclei are studied in terms of the impulse approximation. The principal aim is to reconcile the large polarizations produced by complex nuclei with the smaller effects found in nucleon-nucleon scattering. It is shown that these results are not inconsistent and can indeed be understood in terms of simple physical arguments. While, in general, our knowledge of nuclear structure is not adequate for explicit calculation of these effects even in the impulse approximation, it can be shown that for a particular class of nuclei (the deuteron and the α -particle nuclei) the polarization is independent of the nuclear wave-function. Calculations for these nuclei have been carried out in detail, using existing nucleon-nucleon phase shifts. The resulting polarization effects are found to be large, in rough agreement with experiment, although their angular dependence is not satisfactory. It is proposed that a study of polarization in elastic scattering by deuterium and helium be used as a tool for investigation of the nucleon-nucleon interaction. A.

530.145

3449. Nucleon anomalous moment in a cut-off meson theory. M. H. FRIEDMAN. *Phys. Rev.*, **97**, No. 4, 1123-5 (Feb. 15, 1955).

The anomalous magnetic moments of the neutron and proton are calculated to fourth order by using a cut-off meson theory. The value obtained is 1.44 when one uses the same parameters as employed for fitting the meson-nucleon scattering data. A.

530.145

3450. Scattering of fast neutrons and protons by atomic nuclei. G. TAKEDA AND K. M. WATSON. *Phys. Rev.*, **97**, No. 5, 1336-43 (March 1, 1955).

The effects of the Pauli principle on the analysis of the scattering of fast neutrons and protons by atomic nuclei are considered. This modifies the usual multiple scattering treatment of such problems in three ways: (1) It is necessary to agree on a convention for deciding which are "scattered" and which are "nuclear" nucleons. (2) The two-body scatterings obtained from the impulse approximation must be properly antisymmetrized. (3) Exchange corrections occur because of the non-orthogonality of the plane-wave states for scattered particles and the states for bound particles. The latter corrections seem to be negligible for energies sufficiently high that the multiple-scattering approach is expected to be useful anyway. The present analysis is also applicable to other types of multiple-scattering problems. A.

530.145

3451. Approximate reduction of the many-body problem for strongly interacting particles to a problem of self-consistent fields. K. A. BRUECKNER AND C. A. LEVINSON. *Phys. Rev.*, **97**, No. 5, 1344-52 (March 1, 1955).

It is shown for systems of strongly interacting particles that in the limit of very many particles a transformation exists leading to an alternative

problem which can be solved by a self-consistent field method. The transformed wave-function describes "particles" moving in a collectively determined uniform potential; the transformation relating the transformed and original wave-functions determines the amount of incoherence and correlation in the original function. The method appears to be more useful for fermion systems and is illustrated by applications to some aspects of nuclear structure. A.

530.145

3452. Functional analysis and strong-coupling theory. J. HAMILTON. *Phys. Rev.*, **97**, No. 5, 1390-1 (March 1, 1955).

The relation of functional analysis to the Hamiltonian approach to strongly interacting quantized fields is examined. The propagation of fermions in an external unquantized boson field provides the basis for the solutions, as in the Green function method. The functional method may be useful in studying real nucleons and bound states. A.

530.145

3453. Boson-fermion scattering in the Heisenberg representation. F. E. LOW. *Phys. Rev.*, **97**, No. 5, 1392-8 (March 1, 1955).

It is shown that the S -matrix for boson-fermion scattering can be simply expressed in the Heisenberg representation. By performing a time integration one obtains the S -matrix in the Schrödinger representation, which has the same form as the conventional perturbation theory sum over states. Suitably limiting the nature of the intermediate states entering into this sum leads to integral equations for certain matrix elements which are equal to the S -matrix elements on the energy shell. These equations appear in a completely renormalized form. For example, in the fixed source limit, the four pion-nucleon scattering states satisfy the same equation (with different numerical coefficients). The equations are non-linear, but involve only the scattering phase shifts. The equivalent equation for photopion production is linear, and in the fixed source limit can be written down from a knowledge of the experimental scattering phase shifts. The zero-pion-mass theorems of Gell-Mann and Goldberger (concerning the isotopic spin independence of the zero-energy S -wave scattering) and of Kroll and Ruderman [Abstr. 3118 (1954)] follow simply from the formalism. A.

530.145

3454. Strong-coupling theory for the case of pseudoscalar coupling. H. MIYAZAWA. *Phys. Rev.*, **97**, No. 5, 1399-406 (March 1, 1955).

The pseudoscalar pion field in interaction with the nucleon field through the symmetric pseudoscalar coupling is quantized by using the lattice-space method. A strong-coupling approximation is employed to diagonalize the Hamiltonian at each point. The vacuum is represented by a set of rotators, each having excited states. Propagation of this excitation through the lattice points has the character of particles, which are identified as pions and excited states of pions. Nucleons are found to have excited states, the lowest of which has isotopic spin $\frac{1}{2}$ and parity opposite to that of the ground state (one nucleon).

In the pion-nucleon scattering, this state causes a strong attractive force for S -waves with $I = \frac{1}{2}$ and explains the qualitative behaviour of S -phase shifts. A.

530.145

3455. Sachs' theorem on the magnetic moments of nucleons. H. MIYAZAWA. *Phys. Rev.*, **97**, No. 5, 1413-14 (March 1, 1955).

A correction due to nucleon-pair creation is given to Sachs's relationship between the sum of nucleon magnetic moments and the probability of virtual pions forming the state of angular momentum one. It is found that the probability determined by Sachs is considerably modified by this correction. A.

530.145 : 539.18

3456. On the Fermi theory of multiple production of particles in the collision of nucleons. I. L. ROZENTAL'. Letter in *Zh. éksp. teor. Fiz.*, **28**, No. 1, 118-20 (1955) In Russian.

Conservation of momentum is incorporated exactly into the theory and expressions are given for the non-relativistic and extreme relativistic cases.

G. E. BROWN

530.145

3457. On the physically useful boundary conditions of the Schrödinger equation. T. TIETZ. *Ann. Phys. [Leipzig]* **15**, No. 2, 79-81 (1954) In German.

For $l = 0$, the condition imposed by the requirement of quadratic integrability does not exclude the irregular radial function which goes as r^{-1} for small r . However, the requirement that the Hamiltonian is Hermitian does this.

G. E. BROWN

530.145

3458. A hydrodynamical description of many Bose particle systems. T. NISHIYAMA. *Progr. theor. Phys.*, **12**, No. 3, 265-8 (Sept., 1954).

The hydrodynamical description of an interacting many-boson system given in previous papers [Abstr. 55, 2040 (1954)] is studied more carefully by making use of the so-called hydrodynamical approximation in the lattice space, that the expectation value of the particle number in a cell is very large. The commutation relation of the velocity operator due to Landau and Thellung is obtained and the roton spectrum is computed. The phonon spectrum is obtained in relation to the ground state of the system and the sound speed is evaluated for the rigid sphere problem. Further, the relationship to the collective description of Bohm and Pines is discussed. A.

530.145

3459. Wave fields in de Sitter space. K. GOTÔ. *Progr. theor. Phys.*, **12**, No. 3, 311-54 (Sept., 1954).

General wave equations for particles with arbitrary spin values in de Sitter space are investigated. The particles have generally two sorts of spin-like quantum numbers. Solutions of the second-order wave equations, which are to be satisfied by each component of wave-functions, are obtained. They are composed of only discrete modes of wave oscillations. Behaviour of particles and their potentials in spatially small regions are approximately the same as those of particles with certain other corresponding masses in flat space. A.

- 530.145
3460. Relativistic wave equations under the inhomogeneous Lorentz group. K. GOTÔ. *Progr. theor. Phys.*, **12**, No. 4, 409–20 (Oct., 1954).

Relativistic wave equations, which are invariant under the inhomogeneous Lorentz group, are established by referring to the six-dimensional pseudorotation group. It is also investigated what sorts of new degree of freedom arise compared with the case of the ordinary relativistic wave equations under the homogeneous Lorentz group, particularly from the view-point of describing the new unstable particles. The Maxwell field is unaltered and the Dirac field has eight components: this coincides with the case of Pais's ω -formalism. A.

- 530.145
3461. Relativistic covariance in quantum mechanics. O. COSTA DE BEAUREGARD. *J. Phys. Radium*, **15**, No. 12, 810–16 (Dec., 1954) In French.

An expanded account of a theory developed in previous papers in which the state vector is expressed in terms of a three-dimensional Fourier integral for a free particle with spin, and in terms of a four-dimensional integral in the case of a bound particle. The theory attempts to provide a completely covariant formulation of particle equations and is compared with the Tomonaga-Schwinger theory. R. A. NEWING

- 530.145
3462. The stress tensor in wave mechanics. H. W. FRANKE. *Ann. Phys. [Leipzig]* **15**, No. 3–4, 155–6 (1955) In German.

The Schrödinger equation is interpreted as applying to matter which is, under the action of external forces, subject to the classical equation of motion if density-dependent internal forces are presumed to exist. Theorems of classical mechanics are shown to remain valid [cf. Abstr. 2443 (1955)]. P. T. LANDSBERG

- 530.145
3463. On relativistic corrections in the two-body problem. V. N. TSÏTOVICH. Letter in *Zh. éksp. teor. Fiz.*, **28**, No. 1, 113–15 (1955) In Russian.

Prescriptions for calculating the perturbations arising from radiative corrections or a weak external field to the energy levels of positronium are given. G. E. BROWN

- 530.145
3464. Feynman's principle in non-relativistic quantum mechanics. R. OMNÈS. *C.R. Acad. Sci. [Paris]* **240**, No. 5, 497–9 (Jan. 31, 1955) In French.

For the principle see Abstr. 3107 (1948). It is here justified in some simple cases, including the free particle and the particle under a potential $V(r)$. L. S. GODDARD

- 530.162
3465. A remark on H theorem. CHANG-CHUNG-SUEI. *Acta Sci. Sinica*, **3**, No. 1, 1–13 (March, 1954).

It is pointed out that the quantum-mechanical Boltzmann H theorem in the restricted sense (i.e. with explicit consideration of the statistics of the particles constituting the assembly and their interactions) does

not lead directly to the distribution laws for the particles among their various states as is commonly believed, but to the equality of the probability for all states belonging to the assembly as a whole if the assembly is isolated (or to the Boltzmann factor for the probabilities of states belonging to an assembly kept at constant temperature), in agreement with the result of the generalized quantum-mechanical H theorem as given by Pauli. The distribution laws for the particles among their various states may, of course, be deduced from the latter. In the course of proof, the following minor improvements have been introduced: (1) To avoid the restriction due to the conservation of energy in microscopic processes which lead to changes in the states of the particles and thus to equilibrium, the assembly was assumed to be in interaction with a heat reservoir, so that energies might be supplied by or given to it. This is tantamount to changing the study of the entropy for an isolated assembly to that of the free energy for an assembly kept at constant temperature. (2) Interaction energies between the particles which affect the total energy of the system and also the distribution laws for the particles are included. A.

- 530.162
3466. On the derivation of reciprocal relations between irreversible processes. S. R. DE GROOT AND N. G. VAN KAMPEN. *Physica*, **21**, No. 1, 39–47 (Jan., 1955).

The Onsager relations have been derived in a quantum statistical treatment of irreversible processes for scalar phenomena. In this paper the problem of deriving reciprocal relations between the coefficients which describe vectorial and tensorial phenomena is studied. The problem is approached in two different ways. Firstly, it is shown that one can derive from the quantum statistical theory the results concerning fluctuations used in Onsager's theory, which formed the starting point of de Groot and Mazur's proof of reciprocal relations between vectorial or tensorial phenomena. Secondly, a reformulation of the symmetry expressed by the scalar (Onsager) relations is given which can be readily utilized for the phenomenological equations describing vectorial and tensorial processes. In this way the reciprocal relations between the phenomenological coefficients can be derived. The method is applied to heat conduction, diffusion, viscous flow and cross-effects, and also to electrical conduction in anisotropic solids. A.

- 530.162
3467. Fluctuations in simple mechanical models. C. D. GREEN AND D. TER HAAR. *Physica*, **21**, No. 1, 63–72 (Jan., 1955).

The considerations of the statistical aspect of the second law of thermodynamics [Abstr. 3278 (1953)] are extended. The influence of fluctuations in a class of simple models is investigated generally, and expressions found for the mean life and average time of recurrence of non-equilibrium states which agree with previous results. The models include the Lorentz model of conduction electrons in a metal and the Ehrenfest wind-wood model [Abstr. 1789 (1955)]. The results are used to illustrate the time behaviour of an ensemble of such systems. A.

530.162

3468. Statistical treatment of weakly interacting particles in a Newtonian potential. R. W. HART AND W. H. GUIER. *Phys. Rev.*, **97**, No. 4, 841-8 (Feb. 15, 1955).

A distribution function has been obtained for a two-dimensional system of weakly interacting particles which execute bound periodic motion in a Newtonian potential. The failure of the familiar formulae of statistical mechanics to yield bound distributions for such potentials has been avoided by first restricting the available phase space to that corresponding to periodic motion of independent particles, and then determining the most probable distribution of bound orbits. The effect of weak interaction is considered, then, with the aid of the principle of least action. As an illustration, the distribution of mass has been computed for a many-particle system having the same energy and momentum per unit mass as the nine planets, and compared with the actual distribution of planetary mass. A.

530.162 : 536.75

3469. A remark on the definition of entropy in Bose-Einstein and Fermi-Dirac statistics. P. JAUHO. *Ann. Acad. Sci. Fennicae, AI*, No. 180, 6 pp. (1954).

The results of Abstr. 10825 (1954) are extended to include systems obeying either Bose-Einstein or Fermi-Dirac statistics. It is shown that the statistical ($S = k \log W$) and thermodynamic ($\bar{S} = \int \delta Q/T$) definitions of entropy agree if, in a system with constant volume, the equilibrium is defined by requiring the free energy to be an extremum and if a certain determinant, formed from the second derivatives of the free energy, differs from zero. A.

530.162 : 621.391

3470. Information theory and knowledge: remarks on a paper by D. K. C. Macdonald. A. GAMBA. Letter in *J. appl. Phys.*, **25**, No. 12, 1549 (Dec., 1954).

See Abstr. 7143 (1954). Shows by means of an example that "the discovery of a natural law does not mean a gain of information or negentropy but simply means that we are then able to correct some previous mistakes" and that "there seems to be no reason to define information due to new knowledge." T. J. REY

MECHANICAL MEASUREMENTS 531.7

531.711

3471. Calibration of meter line standards of length at the National Bureau of Standards. B. L. PAGE. *J. Res. Nat. Bur. Stand.*, **54**, No. 1, 1-14 (Jan., 1955).

The results of intercomparisons of the total lengths of several metre bars and of calibrations of the sub-intervals of some of these bars for the past twenty years are reported. Information both on the degree of stability of these standards and on the precision with which such measurements can be repeated was obtained. The results are critically analysed and comments made as to the precautions necessary in the precision comparisons of line standards of length. A.

531.715.1 : 535.417

3472. Interferometric control of grating ruling with continuous carriage advance. G. R. HARRISON AND G. W. STROKE. *J. Opt. Soc. Amer.*, **45**, No. 2, 112-21 (Feb., 1955).

A 14 in. ruling engine, whose operation with interferometer control of grating blank position between ruling strokes has been described previously [Abstr. 7576 (1951)], is now being operated with continuous blank advance and control. Displacement of the carriage holding the grating blank is measured in terms of the phase of a fringe system of constant inclination passing across a photoelectric pickup, which produces low-frequency a.c. whose phase is compared with that from a generator measuring the phase of motion of the ruling diamond. Synchronism between diamond and blank is maintained through corrections fed into a differential on the engine screw-worm by a balancing motor operated by phase differences. Grooves straight to one-tenth fringe, up to 9 in. long, can be produced by means of a cam-and-lever system which rectifies the otherwise simple harmonic motion of the diamond carriage. Continuous servo control results in improved elimination of screw errors and engine vibrations, and in simplified circuitry. The needed electronic and interferometric control systems have been found to function reliably over the long periods needed to rule large gratings. A change-gear system permits passage of any desired fractional number of fringes per diamond stroke needed to produce from about 50 000 to 2 000 grooves per inch. The signal-to-noise ratio obtained when green light from an Hg 198 tube is used to illuminate the carriage-translation interferometer is found to permit control over 10 in. of carriage motion, and stepping methods are being studied to permit multiplication of this distance. Plane gratings up to 8 in. in width of ruling and 5 in. in groove length have been produced, which show acceptably low ghost intensities despite original screw errors of more than 50 times the tolerance limit. Error-of-run and fanning appear to be under good control over distances of 8 in. Rapidly occurring random errors previously found have been traced to lateral motion of the diamond carriage and eliminated. Slow irregularities in groove position are ascribed to temperature variations, to which the engine has been found to be 10 times as sensitive as necessary; these are now being removed. Continuous oscilloscope records taken during ruling show that blank positioning is being controlled by servo interferometry to within 1/40 fringe or better, and indicate sources of disturbances whose removal should result in further improvement. A.

531.717 : 532.731

3473. Determination of particle size. B. K. MUKHERJI AND C. BANERJEE. Letter in *Sci. and Culture*, **20**, No. 7, 341-2 (Jan., 1955).

The size of sodium chloride crystals has been determined by a study of the rate of solution as a function of particle diameter in the range 0.65 to 0.30 mm. The surface area of a sample of sodium chloride determined by estimating its mean diameter in this way agreed with the value from an air permeability measurement. J. M. HOUGH

531.717.1 : 535.417

Tolansky gauge for rapid measurement of film thickness. *See Abstr.* 3651

531.724

3474. The estimation of the specific surface of a soil from mechanical analysis data. J. R. H. COUTTS. *Brit. J. appl. Phys.*, 6, No. 3, 90-1 (March, 1955).

A method by which an approximate value for the specific surface of a soil can be calculated from particle size distribution data is described. Factors affecting the accuracy of the results are discussed. A.

531.728

3475. Precise measurements of particle surface area with the microscope. F. D. PIDGEON AND C. G. DODD. *Analyt. Chem.*, 26, No. 11, 1823-8 (Nov., 1954).

The projected-area method has been modified for direct microscopic measurement of the specific surface areas of non-porous particulate matter, such as convex, irregularly shaped, crystalline particles. The new graticule projected-area method combines the accuracy and advantages of projected-area measurements with the speed of eye-piece graticule comparison procedures. The need for measuring or assuming "shape factors" and for determining suitable statistical methods for averaging size-distribution data, as in measurements of particle "diameters," is eliminated. The method is accurate and direct and requires only 2 to 6 hours per sample compared with several days by earlier procedures. Microscopic surface-area measurements based on the projected-area principle require samples mounted in random orientation. Mounting techniques have been developed which permit extension of method to subsieve-size particles. Comparisons of results on crushed quartz powders with surface areas measured by gas adsorption and liquid permeation indicate good agreement for samples that do not have an appreciable number of particles below 1 to 3 microns. An extension of the method to particles smaller than 1 micron is suggested. A.

MECHANICS OF FLUIDS 532

532.122 : 534.22

Ultrasonic velocity and adiabatic compressibility of hydrocarbon mixtures. *See Abstr.* 3506

532.13 : 535.557 : 541.64

3476. A theory of the Maxwell effect for solutions of chain macromolecules. R. CERF. *C.R. Acad. Sci. [Paris]* 240, No. 5, 531-3 (Jan. 31, 1955) In French.

Theoretical. The method of Rouse [Abstr. 6510 (1953)], based on division of the chains into sub-molecules, is applied to flow birefringence, neglecting Brownian rotation. J. HAWGOOD

532.133 : 532.77

3477. The viscosity of regular solutions. Systems involving carbon tetrachloride, benzene and cyclohexane. L. GRUNBERG. *Trans Faraday Soc.*, 50, Pt 12, 1293-303 (Dec., 1954).

The viscosity of solutions is discussed and it is shown that the equations proposed by Eyring and by Grunberg and Nissan can be used to calculate an

interchange energy, $w_{\text{visc.}}$. The viscosity of the systems benzene + cyclohexane, carbon tetrachloride + cyclohexane and carbon tetrachloride + benzene was measured at 25°C and the values of $w_{\text{visc.}}$ were compared with those of w , the interchange energy derived from measurements of partial pressure. $w_{\text{visc.}}$ is usually several times greater than w and this is tentatively explained by constraint on molecular shape in the solutions. The viscosity equations are shown to be applicable to data taken from the literature. A.

532.133 : 534.2

3478. The viscosity of volume. III. A. CARRELLI AND F. CENNAMO. *Nuovo Cimento (Ser. 10)* 1, No. 3, 365-71 (March, 1955) In Italian.

For Pt II, see Abstr. 8945 (1954). A method for the determination of the ratio η'/η . Results are given for water at the frequency $\nu = 1.8 \text{ Mc/s}$. A.

532.133 : 541.182.6

3479. Studies of the viscosity and sedimentation of suspensions. III. The sedimentation of isometric and compact particles. S. GUREL, S. G. WARD AND R. L. WHITMORE. *Brit. J. appl. Phys.*, 6, No. 3, 83-7 (March, 1955).

For Pt II, see Abstr. 2408 (1951). Series of experiments on the sedimentation of a variety of isometrically-shaped bodies are described, and it is shown that the resistance to motion R , of a body moving with velocity v , in an infinite extent of fluid in the region of streamline flow is given by $R = v\eta K\sqrt{\text{surface area of body}}$, where η is the viscosity of the fluid and K a shape factor of the particle which varies from $3\sqrt{\pi}$ for spheres to $3\sqrt{2} \cdot 92$ for tetrahedra. By using a value of $3\sqrt{3}$ for K the equation may be applied to isometric and other compact shapes, where the axial ratio does not exceed about 1.4 to 1, with an error not greater than $\pm 2\%$. A more accurate, but less easily applied, empirical relationship for the settling rate of compact bodies is also given and an equation which satisfies the interference effects of the walls of a sedimentation vessel upon a falling body is developed experimentally. A.

532.51 : 538.3

3480. A general variational principle for dissipative systems. II. J. W. HERIVEL. *Proc. Roy. Irish Acad.*, 56 A, No. 6, 67-75 (Nov., 1954).

The variational principle put forward in Pt I [Abstr. 8950 (1954)] is re-expressed in a form which may be applied (in principle) to any thermodynamical system. In the case of the electromagnetic field with conduction it leads to the derivation of the second set of Maxwell equations from the first set, and conversely. The application of the principle to a mixture of fluids is considered, and the accepted first-order equations of motion for the two-fluid model of liquid Helium II derived as an illustration. A.

532.517 : 536.24.01

Some remarks on heat and mass transfer across the boundary layer. *See Abstr.* 3673

532.517.4 : 532.7

3481. On the decay of turbulence. F.-K. CHUANG. *Acta Sci. Sinica*, 2, No. 3, 187-200 (Sept., 1953).

The macrostructure of turbulent flow is discussed

as a supplement to Kolmogoroff's study of the micro-structure, and it is shown how the viscous forces are important only in a limited number of regions in the fluid. The transfer of mass, heat, etc., are determined, largely by motion of the large eddies. Kolmogoroff's decay law is extended, and it is shown that Lin's decay law is a particular case of the one developed in the present paper. An analysis, similar to that developed by Sedow, for the correlation coefficients is applied to the turbulent spectrum, and the transition of the decay law from the initial to the final period is derived, together with the approximate transfer function, and it is shown that, near the final period of decay, the effect of the transfer terms is equivalent to an eddy viscosity.

J. S. G. THOMAS

532.59

3482. Visualization of a billow. M. BURESTE. *J. Phys. Radium*, **15**, No. 12, 69 S-70 S (Dec., 1954) In French.

Discusses the determination of the velocity of the particles in a billow, and other characteristics of the flow, by the chrono-photography of Al powder contained in water set into motion in a channel provided with valves at appropriate positions. Trajectories of the particles can be followed during several periods. Absolute velocities of the particles can be determined with an accuracy of 5%. If, in the main, the experimental results confirm Stokes's theory, Miche's work is shown to be closer to reality. But the axes and velocities of rotation and entrainment show anomalies in their variation.

J. S. G. THOMAS

532.595

3483. Self-excited oscillations in an open circular water tank. A. M. BINNIE. *Phil. Mag.*, **46**, 327-37 (March, 1955).

When a vertical or inclined nozzle is fixed in an open tank with its outlet flush with the surrounding water, the jet from the nozzle is irregularly disturbed by waves due to the fall of the jet. Small-scale experiments in a circular basin showed that, if the nozzle were properly sited and trained, and supplied at the correct pressure, the water in the basin could be thrown into one of its natural states of stationary oscillation. The jet then pulsated in an almost steady manner that was much more interesting to contemplate than an irregular or monotonously uniform jet. A simple, approximate theory is put forward to explain the maintenance of the self-excited oscillations in the basin.

A.

CAPILLARITY 532.6

532.612.3 : 548

3484. Surface tension in ionic crystals. M. M. NICOLSON. *Proc. Roy. Soc. A*, **228**, 490-510 (March 22, 1955).

The calculation of surface tensions in crystals of NaCl type is described, with particular reference to the (100) planes. In the cases investigated, the surface tension was greater than the corresponding surface energy by a factor of about 5. An account is given of experimental work carried out to confirm the presence of these surface forces. The basis of the

method used was the measurement of the unit-cell dimensions of small crystals compared with those of normal size. As the particle size is diminished, surface forces of the order of those calculated should cause a gradual change in the unit-cell dimensions which becomes measurable by standard X-ray powder technique before line broadening masks the effect. Samples of small crystals of magnesium oxide and sodium chloride, whose particle size was determined by means of the electron microscope and by measurement of line broadening, were prepared and were found to show changes in the unit-cell dimensions of the sign and order of magnitude expected, provided that surface layers of adsorbed gases were absent. A.

MOLECULAR THEORY OF LIQUIDS 532.7

532.7

3485. A study of air absorption of some liquids. G. L. DE AND P. C. MAHANTI. *Indian J. Phys.*, **28**, No. 9, 441-7 (Sept., 1954).

In highly refined samples of transformer, linseed, groundnut and sesame oils and in distilled water, the absorption per cm^3 in time t min is $\alpha \approx \alpha_0(1 - e^{-t/\lambda})$ where α_0 is the max. absorption and λ a constant, characteristic of each liquid. The absorption decreases with increasing polarity of the liquids. J. H. MASON

532.7

3486. Dislocation model of liquids. J. ROTHSTEIN. Letter in *J. chem. Phys.*, **23**, No. 1, 218-19 (Jan., 1955).

Envisages melting as the coagulation of vacancies or interstitial atoms into sheets, which thus form dislocations. Qualitative discussion. R. S. PEASE

532.7 : 532.13 : 537.311.35

3487. Contribution to the theory of conductivity and viscosity of molten salts. W. OLDEKOP. *Z. Phys.*, **140**, No. 2, 181-91 (1955) In German.

A simple model of molten salts, particularly alkali-halogenides, is developed on the basis of Green's theory of liquids, giving an order-of-magnitude agreement with experiment. T. P. BRODY

532.72

3488. Methods of describing unidimensional diffusion in binary liquid systems. A. G. OGSTON. *Trans Faraday Soc.*, **50**, Pt 12, 1303-11 (Dec., 1954).

The thermodynamic and kinetic expressions of diffusion in liquid systems are compared, with particular attention to the statistical basis of the latter, and to the expression of non-ideal behaviour. Kinetic non-ideality arises if either the mean step-length δ' , or the specific rate k at which unit displacements occur, varies with the concentration. The various equations for the diffusional flux show a correspondence between their respective terms. Introduction of absolute rate theory suggests that the effect of varying k is to be identified with that of varying activity coefficient γ in the thermodynamic treatment. However, the effect of varying δ' does not appear to be identifiable with variation of γ . This raises a problem which is stated, but not solved. A.

532.72 : 532.133 : 541.64

3489. Intrinsic viscosity of flexible macromolecules: Corrected tables. J. G. KIRKWOOD, R. W. ZWANZIG AND R. J. PLOCK. Letter in *J. chem. Phys.*, **23**, No. 1, 213-14 (Jan., 1955).

See Abstr. 3640 (1948). An error in the solution of an integral equation is rectified. A description of the method of numerical solution of such equations and a numerical table of corrected intrinsic viscosities is given. C. TURNER

532.72 : 535.417

3490. Intensity measurements applied to Gouy diffusiometry. J. F. RILEY AND P. A. LYONS. *J. Amer. Chem. Soc.*, **77**, No. 2, 261-4 (Jan. 20, 1955).

A method is described which has been used to verify the intensity distribution in the lower fringes in a Gouy diffusion fringe pattern predicted by the general theory for the Gouy method. The position of the zeroth turning point predicted by the theory has also been shown to be correct. Two techniques for the direct recording of Gouy diffusion data for use in the actual determination of diffusion coefficients are presented briefly. A.

532.72 : 535.417

Determination of diffusion constants. See Abstr. 3652

532.731 : 531.717

Determination of particle size. See Abstr. 3473

532.785 : 548.5

3491. The concentration of the solution round a growing crystal. S. P. F. HUMPHREYS-OWEN. *Acta cryst.*, **8**, Pt 2, 112-13 (Feb., 1955).

Goldsztub and Kern [Abstr. 2088 (1954)], employing a new experimental technique, were unable to confirm the previously reported observation that the concentration at, or very near to, a growing crystal face is not uniform. It is pointed out that there has been an overestimate of the sensitivity of this new method, and that the negative result may thus be explained. A.

MECHANICS OF GASES 533

533.5

3492. Electrical discharges and the vacuum physicist. F. LLEWELLYN JONES. *Vacuum*, **3**, No. 2, 116-27 (April, 1953; publ. Dec., 1954).

Discusses briefly the various kinds of discharges which can occur in evacuated apparatus, i.e. for pressure ranges approximately equal to or smaller than 10^{-4} mm Hg when the mean free path is of the order of dimensions of the apparatus. Under these conditions the processes of ionization in the gas are not always the predominating processes of either initiation or maintenance of such discharges, which are then greatly dependent upon the nature of the electrode surfaces. The mechanisms of the various discharges which can be produced in this way are briefly discussed, and an indication given of the importance of the possible rôles played by magnetic fields and by the nature of the electrode surfaces. A.

533.5

3493. The electronic clean-up of gases in sealed-off vacuum systems. R. N. BLOOMER AND M. E. HAINE. *Vacuum*, **3**, No. 2, 128-35 (April, 1953; publ. Dec., 1954).

Some of the previous work in this field is reviewed briefly, and a few of the conflicting theories put forward to account for the observations are mentioned. The results of fresh experiments, using sealed-off tungsten filament triode ionization gauges, are described. In the clean-up of gas in these tubes, two regions of the log P *v.* time curves are distinguished. The speed of pumping or cleaning-up of gas in each region is constant, and hence the rate of cleaning-up of gas is proportional to pressure. In the first or "A" region of the falling pressure/time curves, the speed of pumping is a few $\text{cm}^3 \text{sec}^{-1}$; in the second or "B" region, the speed is about 1/20th as great. In the "A" region, the speed of pumping is proportional to the ionizing electron current, but in the "B" region it is independent of electron current for values greater than a few tens of microamperes. It has been found that the cleaned-up gas is held by the glass walls of the tubes, particularly in the vicinity of the electrode structure. When all the glass was shielded from the products of the ionizing electron current, clean-up of gas ceased. The significance of the two regions of the clean-up curves is discussed, and possible mechanisms are suggested in keeping with the observations in the greater part of the present experiments, and those reported by previous workers. A.

533.5

3494. A high temperature resistance-heated high vacuum furnace. W. J. KRAMERS AND F. DENNARD. *Vacuum*, **3**, No. 2, 151-8 (April, 1953; publ. Dec., 1954).

An experimental 10 kW vacuum furnace which can be assembled from standard vacuum coating equipment to operate directly from the a.c. mains through a transformer. Promising operational results have been obtained and the design is suitable for the construction of larger furnaces on the same principle. The cost is about half that of an induction furnace of similar size and performance. A.

533.5 : 531.788

3495. A Pirani gauge circuit. C. N. W. LITTING. *J. sci. Instrum.*, **32**, No. 3, 91-2 (March, 1955).

A detector circuit employing a germanium rectifier is used in conjunction with a direct-reading constant-temperature type of Pirani gauge. By this means a near linear calibration is obtained. A.

533.6.011.31

3496. Interferometric investigation of flow past turbine blade cascades. L. M. ZYSINA-MOLOZHEN AND I. G. SHAPIRO. *Zh. tekhn. Fiz.*, **24**, No. 6, 978-88 (1954) In Russian.

Interferograms are presented for two types of blades at Mach numbers from 0.35-0.70 and a blade spacing/chord ratio of 0.68. Advantages of the method for rapid determination of aerodynamic properties of turbine blades are discussed. The apparatus has been described previously by the

authors [Sbornik rabot TsKTI *Teploperedacha i aerodinamika* (Heat Transfer and Aerodynamics), Vol. 7, Book 27, 1953] and is only illustrated here.

A. GELBTUCH

533.6.011.31

3497. The flow due to impulsive motion of a wedge and its similarity to the diffraction of shock waves. A. SAKURAI. *J. Phys. Soc. Japan*, 10, No. 3, 221–8 (March, 1955).

An analysis is performed to clarify the non-uniform region of the air flow caused by impulsive motion of a wedge with small vortex angle. It is shown that the present problem is quite similar to the well-known problem of the interaction of a shock wave and a wedge. By use of this similarity, some cases of wedges not having small vortex angles are discussed. A.

533.6.011.4 : 536.423.4

3498. Spontaneous condensation in a supersonic flow of humid air. H. WAKESHIMA. *J. Phys. Soc. Japan*, 10, No. 2, 141–8 (Feb., 1955).

The problem of the spontaneous condensation of water vapour in a supersonic flow of moist air is approximately solved on the basis of Becker–Döring's equation for the stationary rate of self-nucleation and on the law of droplet growth. Comparison of the theoretical prediction with experimental results given by Head shows good agreement and thus it is revealed that the major part of the delay in the appearance of condensation, from which some doubt has been cast over the validity of Becker's formula in such cases, can be explained plausibly without the notion of time lag in self-nucleation. A.

VIBRATIONS . ACOUSTICS 534

3499. Acoustics. L. L. BERANEK. *New York: McGraw-Hill Book Company* (1954) 481 + x pp., figs. 330.

Review in *Rev. sci. Instrum.*, 26, No. 1, 71 (Jan., 1955) "designed for . . . advanced undergraduates or first-year graduate students. . . . The introduction includes a list of definitions of the more important acoustical terms. The first five chapters and chapter twelve deal respectively with fundamental topics in acoustics such as solutions to the wave equation, acoustical analogues, radiation, acoustic components, and acoustic measurements. Chapters six to eleven inclusive deal with applications of the fundamental topics to microphone, loudspeaker systems, sound fields in enclosures, and noise control. The last chapter of the book is concerned with hearing, speech intelligibility and psycho-acoustics." A.

534.121.1

3500. Critical review of earlier Chladni figures. M. D. WALLER. *Acustica*, 4, No. 6, 677–80 (1954).

The earlier Chladni figures do not provide an experimental basis for the theory which allows modes of equal frequency, of square and rectangular plates, to combine regardless of the symmetry of the surfaces. Recent experiment has established that such additional modes are impossible. A.

534.13

3501. Electrical equivalent circuit for the modes of oscillations of piezo-electric bars. P. CHALOUPEK. *Czech. J. Phys.*, 4, No. 4, 453–62 (Nov., 1954).

The equivalent circuits for odd and even longitudinal, flexural and torsional vibrations of piezo-electric bars are calculated by means of series development for various ways of excitation. The effect of coupling due to internal frictions is neglected. A.

534.154

3502. Absolute measurements of micro-acoustic vibration. S. NISHIYAMA. *J. Inst. Elect. Commun. Engrs Japan*, 37, No. 6, 421–5 (June, 1954) In Japanese.

An e.s. vibrograph and an e.s. vibrometer are combined to transmit the velocity, phase and other quantities to be measured to the vibration elements of the vibrometer. The microvibration parameters can then be calculated from the mechano-motive force and the mechanical impedance. Theory of the method is given and the calibration of the equipment is described. Experimental results for the distribution of the displacement of a planar vibrating diaphragm are shown graphically. A. WILKINSON

534.21 : 541.18.047

3503. Coagulating mechanism of acoustic current. P. N. KUBANSKIĬ. *Zh. tekhn. Fiz.*, 24, No. 6, 1049–54 (1954) In Russian.

The coagulating effect is not due only to the Bernoulli force and radiation pressure but also to the acoustic current, i.e. Rayleigh's vortex circulation due to viscosity. Experiments are described to confirm the theoretical calculations. J. M. HOUGH

534.213

3504. Sound propagation in granular substances. H. SCHMIDT. *Acustica*, 4, No. 6, 639–52 (1954) In German.

In granular substances in the form of rods there appear longitudinal, flexural and torsional waves. The elastic modules and the loss factor are each dependent on the static pressure so that their values vary with the layer thickness. In dry sand and glass spheres in layers 3 to 11 cm thick the longitudinal velocity was found to lie between 100 and 170 m/sec. The loss factor lay between 6 and 12×10^{-2} . In sharp-edged materials such as brick chips and coal dust the longitudinal velocity was independent of the thickness and amounted to approx. 80 m/sec. The velocity could be reduced by the addition of a soft material. In the second part of the work the damping of waves in a solid body due to a layer of sand is reported. There occurs in such combinations a damping maximum at the frequency at which the layer of sand is in resonance. This behaviour is explained theoretically and confirmed by measurements of the sound velocity and damping in an aluminium rod coated with sand. A.

534.22

3505. Measurements of the velocity of ultrasound in sea water (Black Sea and the Sea of Marmara). C. ENER AND N. Ş. TAŞKÖPRÜLÜ. *Rev. Fac. Sci. Univ. Istanbul C*, 19, No. 2, 105–9 (April, 1954).

The measurements were made at 5 Mc/s by the optical diffraction method. (The sea of Marmara is

one of the few bodies of water on the earth in which a discontinuity in salinity persists throughout the year.) Observed sound velocities at various salinities (about 16 p.p.t. to 35.5 p.p.t.) are consistently higher than the values calculated with the Kuwahara formula. The adiabatic compressibility and sulphate/chloride ratio were also determined. A.

534.22 : 532.122

3506. Ultrasonic velocity and adiabatic compressibility of hydrocarbon mixtures with one component having a branched structure. F. DANUSSO. *R.C. Accad. Naz. Lincei*, 17, No. 3-4, 109-13 (Sept.-Oct., 1954) In Italian.

Determinations of molecular volume V , ultrasonic velocity u , and molecular adiabatic compressibility B , have been obtained at 30°C for binary mixtures of cyclohexane, benzene, ketane, and decaline with isotane, which has a branched structure. The percentage deviations ΔV , Δu and ΔB at various concentrations are tabulated and graphically compared with the calculated theoretical values assuming that the given systems are ideal. Using isotane as the common component, ΔV and B are less than, and Δu is greater than the corresponding deviations obtained using n -heptane, which has a linear structure, as the common component. See also Abstr. 4663 (1953). J. J. PHIPPS

534.22 : 532.122

3507. Ultrasonic velocity and adiabatic compressibility of alcohol mixtures. F. DANUSSO. *R.C. Accad. Naz. Lincei*, 17, No. 3-4, 114-20 (Sept.-Oct., 1954) In Italian.

See also Abstr. 4663 (1953) and preceding abstract. The percentage deviations of molecular volume V , ultrasonic velocity u , and molecular adiabatic compressibility B , at 30°C, are tabulated and graphed for 13 binary systems of cyclohexanol alcohol with each of methyl-, n -propyl-, iso-propyl-, n -butyl-, iso-butyl-, octil-, alcohols, glycol and glycerine. Excepting the glycerine-cyclohexanol system, to be studied further, the deviations ΔV , Δu and ΔB are of the same type, having the same regularity, as those for the previously studied hydrocarbon mixtures.

J. J. PHIPPS

534.22 : 532.7

3508. Basis and intuitive interpretation of the Rao formula for sound velocity. W. SCHAAFFS. *Acustica*, 4, No. 6, 635-9 (1954) In German.

The Rao relation between the velocity of sound in non-associated liquids and the molar volume is derived from a theory of the author, according to which the velocity in organic liquids is proportional to the packing of the molecules. An atomic interpretation is thus given to Rao's empirical formula. The additive effect (due to various molecular groups) differs from Rao's values in that the molar volume is replaced by a proportionate value, also independent of temperature, which lies between the molar volume and the molecular volume per mole. The designation "molar sound velocity" which is frequently used for the expression of Rao is therefore incorrect. A.

534.22 : 532.7

3509. Measurements by optical methods of the sound velocity in aqueous solutions of electrolytes in depen-

dence on concentration and temperature. K. TAMM AND H. G. HADDENHORST. *Acustica*, 4, No. 6, 653-7 (1954).

The sound velocity in aqueous solutions of electrolytes has been measured at various concentrations by counting the Hiedemann-fringes within a known distance by means of a photoelectric cell and an electronic counter. The temperature dependence has been determined by observation of the periodically occurring "temperature resonances" in a stationary ultrasonic wave. In the 2-2-valent electrolyte solutions investigated, the sound velocity increases linearly with concentration. The dependence on temperature shows as in water an anomalous parabolic course; its maximum, however, is shifted to lower temperatures. The results can be explained by assuming aggregates of water molecules. A.

534.22 : 532.7

3510. Sound velocity and constitution in organo-silicon compounds. G. KANNEBLEY AND W. SCHAAFFS. *Acustica*, 4, No. 6, 661-4 (1954) In German.

The velocities of sound and densities of seventeen liquid organo-silicon compounds are measured. Further the velocities of sound are calculated according to the theory of W. Schaaffs, by which the velocity of sound is proportional to the filling of the space with molecules and obeys additive laws. The agreement between measurement and calculation is satisfactory. A.

534.222.2

3511. Shock waves in binary mixtures. S. P. D'YAKOV. *Zh. éksp. teor. Fiz.*, 27, No. 3(9) 283-7 (1954) In Russian.

The structure of weak shock waves in binary mixtures is studied, account being taken of diffusion, thermal diffusion and barodiffusion. Equations are developed for the thickness of the shock wave, and pressure, entropy and component distributions. These equations are then applied to (1) a mixture of ideal gases, and (2) a suspension of solid particles in a gas. For (1), the component concentration is calculated for weak, and estimated for strong, shock waves. In (2), the concentration of solid particles in the shock wave is found to be reduced and the shock wave is found to be much thicker than in a homogeneous mixture. A. GELBTUCH

534.222.2

3512. On the stability of shock waves. S. P. D'YAKOV. *Zh. éksp. teor. Fiz.*, 27, No. 3(9) 288-95 (1954) In Russian.

A characteristic frequency equation is developed for two-dimensional stationary compression and rarefaction shock waves of any intensity in an arbitrary medium, from which conditions of instability are deduced when disturbances increase exponentially with time. Conditions under which sound is emitted spontaneously by the shock wave are established. The results are applied to several types of Hugoniot and discussed qualitatively. A. GELBTUCH

534.222.2

3513. An exact solution of the spherical blast wave problem. J. L. TAYLOR. *Phil. Mag.*, 46, 317-20 (March, 1955).

534.23
3514. Effects of diffusion on the absorption of ultrasonics in gas mixtures. S. PETRALIA. Letter in *Nuovo Cimento* (Ser. 10) 1, No. 2, 351-4 (Feb., 1955) In Italian.

Continuation of the work described in Abstr. 7206 (1954). Values of α/f^2 as a function of concentration for the mixtures He-Kr, He-Ne, Ne-A, A-Kr and Ne-Kr are shown graphically and tabulated. The values are compared with those calculated from Kohler's relation (*Ann. Phys. [Leipzig]* 39, 209 (1941)).

S. WEINTROUB

534.23
3515. Velocity and absorption of ultrasonics in liquid sulfur. A. W. PRYOR AND E. G. RICHARDSON. *J. phys. Chem.*, 59, No. 1, 14-16 (Jan., 1955).

In order to derive some of the visco-elastic properties of liquid sulphur, particularly in the transition region where polymerization takes place, measurements of ultrasonic velocity and attenuation over the range of temperature 100 to 250° have been made. Comparison is made between the "ultrasonic viscosity" deduced from such measurements and those derived in a conventional viscometer. A model is suggested to account for the acoustic behaviour of sulphur above 160°.

A.

534.23
3516. Measurements of ultrasonic absorption in rubber. I. GABRIELLI AND G. JERNETTI. *Nuovo Cimento* (Ser. 10) 1, No. 3, 403-13 (March, 1955).

Absorption measurements of ultrasonic longitudinal waves in vulcanized natural rubber with and without carbon loading (50/100 carbon to rubber) are presented within the temperature and frequency ranges from 4°C to 70°C and from 0.4 Mc/s to 4 Mc/s. Experimental data were obtained by measuring, with a torsion balance, ultrasonic attenuation due to rubber samples immersed in water. Diagrams of absorption v . temperature for carbon-loaded natural rubber show the usual behaviour of vulcanized rubbers. Corresponding diagrams for unloaded natural rubber show minima which indicate discrimination between two different relaxation effects. An unusual example of absorption decreased by carbon loading has been detected.

A.

534.23 : 532.7
3517. The propagation of sound in solutions of rubber and Perspex. A. W. PRYOR. *Acustica*, 4, No. 6, 658-61 (1954).

The absorption of ultrasonic waves in the frequency region 4 . . . 18 Mc/s was measured in several highly viscous solutions of rubber in benzene and Perspex in pyridine. The absorption was less than in the pure solvents and there is evidence of relaxation. Measurements of the shear viscosity of a 10% rubber solution showed that the relaxation of the high flow viscosity was complete even at 50 kc/s. The absorption in the solutions must therefore be ascribed to the "bulk viscosity" of the solvents.

A.

534.23 : 539.374
3518. Ultrasonic attenuation in zinc single crystals while undergoing plastic deformation. G. A. ALERS. *Phys. Rev.*, 97, No. 4, 863-9 (Feb. 15, 1955).

The attenuation of 7 Mc/s ultrasonic pulses in zinc

single crystals before, during, and following plastic deformation has been measured using the ultrasonic pulse technique. Simultaneous measurements of the time-dependent plastic strain at constant stress were made in order to study the correlation between this strain and the attenuation. The crystals were oriented in such a way that the applied stress was a direct shear on the slip plane, thus causing the deformation to proceed only by slip over this plane. At the same time the high-frequency sound pulses were sent through the crystal perpendicular to the slip plane. It was found that the attenuation of transverse waves, whose stress vectors lay in the slip plane, was very sensitive to the deformation. Longitudinal waves, with stress vectors perpendicular to the slip plane, were substantially unaffected by the deformation. This indicates that the attenuation was caused by dislocations introduced with the deformation and moving only in the slip plane. The time-dependent changes in the attenuation and the strain enabled the motion of these dislocations to be studied. For small plastic strains, the attenuation of the transverse waves rose during the loading process, but decreased again after the load was completed even as the crystal continued to deform with time. For larger strains, the attenuation continued to rise after the load was completed and was nearly proportional to the strain. Upon unloading, the attenuation recovered very rapidly toward its value before deformation. If the unloading was carried out in steps, the attenuation decreased while the crystal rested under some intermediate load. When this load was decreased still further, the attenuation rose very rapidly until the unloading was stopped, after which time the crystal again rested under constant stress and the attenuation again decreased. A.

534.232 : 621.395.623.7

3519. Characteristic curves of the directivity of electroacoustic transducers. A. C. RAES. *Ann. Télécomm.*, 9, No. 11, 313-14 (Nov., 1954) In French.

An experimental method is described which does not require the use of an acoustic room. The loudspeaker on test is energized by sound which reaches its maximum intensity sufficiently rapidly (within 5 msec), that it can be registered by a detecting microphone near the loudspeaker before any reflected waves from the walls of the room reach the microphone. Results are given of tests which agree reasonably with the calculated values.

G. F. HODSMAN (R)

534.321.9 : 532.623
3520. The degassing of liquids in an ultrasonic field. A. P. KAPUSTIN. *Zh. tekhn. Fiz.*, 24, No. 6, 1008-11 (1954) In Russian.

Waves of 0.6 Mc/s from a quartz oscillator were used in transformer oil and glycerine. Degassing took place in two stages, formation of bubbles and then their transport to the surface. The time to degas decreased with increasing intensity of the sound waves.

J. M. HOUGH

534.61
3521. Study of a detector of ultrasonic energy. M. DEGROIS. *Ann. Télécomm.*, 10, No. 1, 2-7 (Jan., 1955) In French.

Following a brief review of existing methods of obtaining the directivity of ultrasonic projectors, an

apparatus involving a thermocouple detector is described. Its construction, method of use and calibration are given in detail. The apparatus is simple and enables measurements to be made in liquids without errors due to temperature variations in the liquid bath.

G. F. HODSMAN

534.612

3522. A new sound integrator. R. T. JENKINS. *Bell Lab. Record*, **32**, No. 9, 331–5 (Sept., 1954).

The device to be measured is placed on a fixed table at the centre of a hemisphere. Four microphones mounted on a frame are rotated in a horizontal plane, each being supported in the middle of one of four zones of equal height (i.e. of equal hemisphere area). The sound power of the source is a sum of the integrations over each of the zones. The microphones are switched into the power-level indicator by a commutator which controls the sequence of sampling so that the whole field is covered after 4 revolutions (3.2 sec). A frequency analyser enables the power in any particular bandwidth to be determined. For the overall bandwidth, powers down to $0.05 \mu W$ can be measured.

A. J. KENNEDY

534.614

3523. On the application of the impulse method to the determination of the velocity of ultrasound. E. I. CHUIKIN. *Zh. tekhn. Fiz.*, **24**, No. 6, 1125–35 (1954) In Russian.

A mathematical study of the effect of absorption on the shape of the transmitted pulse of ultrasound. It is shown that the pulse shape is considerably altered by absorption and that this may effect the value of the velocity obtained.

J. M. HOUGH

534.7

Physiological acoustics. Hearing. See also under "Medical science. Human physiology." Decimal classification 612.85

534.771

3524. Copying [Nachbildung] of the human hearing level. H. HUDLER. *Österr. Z. Telegr.-Teleph.-Funk-Fernsehtech. [ÖTF]*, **8**, No. 9–10, 113–22 (Sept.–Oct., 1954) In German.

The design of an improved form of audiometer is described, the instrument covering continuously the frequency range 50 c/s to 15 kc/s and not, as is more usual, operating at specific fixed frequencies. The earpiece, whatever its form, was assumed to have a flat frequency response and accordingly the instrument was designed to trace out automatically any equal-loudness curve within the whole hearing range of 130 db—as at 2 kc/s—as the generator frequency is swept. Difficulties arising from the wide dynamic range required and from the necessity to suppress noise and hum are discussed. The final design takes the form of a generator feeding through an "equalizer" [Nachbildung], a combined second equalizer and variable attenuator and a power amplifier into a second variable attenuator. The design of the second equalizer, a 15-stage attenuator consisting of RC networks of different time constants, is described in detail.

H. G. M. SPRATT

534.838

3525. Measurements of the input impedance of the soil with the object of vibration insulation. T. S. KORN

AND F. KIRSCHNER. *Acustica*, **4**, No. 6, 671–6 (1954) In German.

Resilient mountings, inserted between a source of vibration (unbalanced rotary machines, etc.) and the foundation, may sometimes produce an increase of transmitted vibrations. This phenomenon cannot be explained on the basis of the usual simple theory. The improved theory must include the mechanical input impedance of the foundation in the complete vibrating system. The present paper describes the development of apparatus for measuring that impedance, and of a simplified model thereof, and measurements of transmitted vibrations for different values of the input impedance of the foundation, results of which confirm the theory. The authors discuss also the validity of the conventional quantity "transmission coefficient" when the input impedance of the foundation is modified and suggest the use of the quantity: "Ratio of apparent powers."

A.

534.84

3526. Review of architectural acoustics during the past twenty-five years. V. O. KNUDSEN. *J. Acoust. Soc. Amer.*, **26**, No. 5, 646–50 (Sept., 1954).

534.843

3527. Definition and diffusion in rooms. E. MEYER. *J. Acoust. Soc. Amer.*, **26**, No. 5, 630–6 (Sept., 1954).

534.844 : 621.396.712.3 : 621.395.625.3

3528. Artificial reverberation. P. E. AXON, C. L. S. GILFORD AND D. E. L. SHORTER. *Proc. Instn Elect. Engrs, Paper No. 1796 R*, publ. Feb., 1955, 17 pp.

The demand for a source of artificial reverberation in sound transmission systems is commonly met by the use of reverberation rooms, but attempts have been made to fulfil the requirements by devices involving the transmission of the signal through a number of delay channels. The design and operation of such devices can be treated by simple theory, but in the present state of the art, the quality of artificial reverberation, like that of the natural product, cannot be completely assessed except by ear. The characteristics of artificial-reverberation apparatus employing delay channels with overall feedback are discussed and illustrated by the results of early experiments using acoustic-delay tubes. The acoustic-tube system, while simple in principle, involves in practice much instrumental complication and becomes uneconomic if good sound quality and long reverberation time are required. Artificial-reverberation apparatus employing a magnetic-recording delay system, which is free from the defects associated with the acoustic tube, is described. By means of a double recording track, the effective number of delay paths is greatly increased and a high standard of performance is thus attained. This equipment has been in regular use by the B.B.C. for $2\frac{1}{2}$ years. Artificial-reverberation systems involving a finite number of delay paths tend to produce flutter effects when transmitting impulsive signals. Such effects can be mitigated by the use of a small auxiliary reverberation chamber. By temporarily transferring the signal to the ultrasonic-frequency region, the required effect can be conveniently obtained with a small water-filled reverberation tank. Details are given of equipment of this type which has been designed for use in conjunction with the magnetic recording system referred to.

A.

534.845
3529. Manufacture and distribution of acoustical materials over the past 25 years. H. J. SABINE. *J. Acoust. Soc. Amer.*, 26, No. 5, 657-61 (Sept., 1954).

534.845.1
3530. Advances since 1929 in methods of testing acoustical performance of acoustical materials. F. G. TYZZER AND H. A. LEEDY. *J. Acoust. Soc. Amer.*, 26, No. 5, 651-6 (Sept., 1954).

534.846
3531. Acoustical improvement of the Budapest State Theatre. T. TARNÓCZY. *Acustica*, 4, No. 6, 665-71 (1954) In German.

Owing to the short reverberation time absorbent materials could not be used. To increase the sound energy a new wood-lined proscenium was built and wooden panelling also used in other parts of the building. To avoid echoes and interference effects diffusing surfaces were employed. New measurements show that the acoustics were considerably improved. Echoes and interference effects were totally suppressed and the sound energy appreciably increased. The reverberation time was increased and its frequency curve improved as a result of boosting at higher frequencies.

A.

534.851.6 : 519.2
3532. Investigation of gramophone record noise on the basis of statistical probability. F. LEGERER. *Frequenz*, 8, No. 11, 343-6 (Nov., 1954) In German.

This is an attempt to assess by mathematical analysis the characteristics of random noise generated in gramophone records. Assuming the use only of crystal pick-up devices, which are velocity-modulation conscious, an acceleration function is determined, which can be shown to be a probability-distributed amplitude curve. This is analysed for its average value and stray limits, expressed by arithmetic mean values of functions $f(t)$ and $[f(t)]^2$. Certain sudden changes and discontinuities in measured noise responses, hitherto considered to be entirely random, are shown to agree with the derived statistical probability characteristics, under certain experimental conditions only, pertaining to the number of independent observations and their individual duration.

A. LANDMAN

534.861.1
3533. Resonant absorption elements employed in the acoustic equipment of broadcasting studios. J. HABANEC. *Slaboproudý Obzor*, 15, No. 11, 508-19 (1954) In Czech.

The natural frequencies and the conditions of maximum absorption (optimum matching), for a normal incidence of sound waves, are calculated for the following types of sound absorbers: (1) flat vibrating plates, (2) cylindrical resonators, (3) absorbing membranes, and (4) Helmholtz resonators with round and square apertures, with slots or filled with absorption materials. The theory is supplemented by experimental results, the measurements being carried out under the conditions of normal and diffuse incidence. Absorption curves for the plate and Helmholtz resonators as a function of the position of the absorption materials are reported; effect of the apertures on the absorption of Helmholtz resonators is examined. The vibrating plates, cylindrical reso-

nators and membranes are found to be satisfactory at low acoustic frequencies, while Helmholtz resonators are efficient absorbers in the medium frequency range.

R. S. SIDOROWICZ

534.862
3534. Recording and reproduction with stereophonic sound film. H. FRIESS. *Funk u. Ton*, 8, No. 12, 622-30 (Dec., 1954) In German.

General problems arising in sound recording for film are discussed, such as the merits and demerits of reverberation. An analysis of the requirements for single-channel and stereophonic sound, with particular references to Cinemascope, covers (1) resolution of pitch, with the accompanying need for absence of wow and distortion; (2) dynamic range; and (3) perception of distance and direction of the source. As a result, the relative merits of the various systems are tabulated in the form of the max. possible number—in each case—of minimum perceptible increments for the various parameters. From it, the superiority of stereophonic sound is clearly shown. Certain Cinemascope equipment is illustrated and briefly described. A complete layout for a theatre installation is shown.

H. G. M. SPRATT

OPTICS . RADIATION . SPECTRA 535

535.12
3535. The use of piezoelectric quartz for observing the Doppler effect. N. SÉGARD AND E. BESÈME. *Ann. Soc. Sci. Bruxelles*, 1, 68, No. 3, 185-92 (1954) In French.

It is calculated that to observe the Doppler effect with light reflected from quartz it would be necessary to have several reflections from a surface of at least 1 cm², vibrating with a frequency greater than 200 000 c/s, with an amplitude approaching the rupture value.

G. F. LOTHIAN

535.14 : 538.3
3536. A derivation of Maxwell's equations for the vacuum with the help of a model energy quantum. H. ZUHRT. *Arch. elekt. Übertragung*, 8, No. 10, 447-56 (Oct., 1954) In German.

The unperturbed photon of energy $h\nu$ is assumed to be a spherical shell of mass $h\nu/c^2$ with spin $2\pi\nu$ about an axis perpendicular to the direction of translation. The assumption that energy is divided equally between rotational (magnetic) and translational (electric) kinetic energy gives the radius of the shell to be $(c/2\pi\nu)\sqrt{(3/2)}$ and the spin momentum $h/2\pi$. Interference phenomena are accounted for by suitable assumptions concerning photon-photon perturbations. The spin axis is taken parallel to the magnetic field, and the model is claimed to be consistent with the electromagnetic equations.

R. A. NEWING

535.23.08
3537. Effects of recent knowledge of atomic constants and of humidity on the calibrations of the National Bureau of Standards thermal-radiation standards. R. STAIR AND R. G. JOHNSTON. *J. Res. Nat. Bur. Stand.*, 53, No. 4, 211-15 (Oct., 1954).

The National Bureau of Standards thermal-

radiation standards, as established and maintained since 1913, are based primarily upon the emission of a blackbody, using the Stefan-Boltzmann constant of total radiation $\sigma = 5.70 \times 10^{-12}$ watt/(cm² deg⁴). The present status of this constant is reviewed in relation to the recent experimental evidence for more accurate values of the velocity of light and for the other atomic constants effecting the value of σ . It is concluded that any change in the Stefan-Boltzmann constant is unimportant at this time. An investigation is reported on the effect of the atmospheric water vapour on the transmitted radiant intensities of these lamps at the working distance of 2 metres. The usual variations in laboratory humidities will affect the certified calibrations of these standard lamps less than 0.3% and hence may be neglected in all radiometric work wherein they are employed.

A.

535.233

3538. Radiation of certain selective bodies in the near infrared. F. DESVIGNES. *Rev. Opt.*, **33**, No. 10, 494-7 (Oct., 1954) In French.

Experiments show that "black" oxides (Ti, Va, Cr, Mn, Fe, Co, Ni) and white oxides (Be, Mg, Al, Si, Th, Zr) all have nearly the same emission at 2μ as tungsten filaments.

G. F. LOTHIAN

535.241.44 : 612.843.367

3539. Effect of a peripheral glare source upon the apparent brightness of an object. G. A. FRY AND M. ALPERN. *Illum. Engng*, **50**, No. 1, 31-8 (Jan., 1955).

Describes measurements of the effect of a glare source in reducing the apparent brightness (luminosity) of a surface, using a binocular matching technique. The equivalent veiling luminance of a source θ^0 from the direction of view, producing an illumination of E lm/ft² at the eye was found to be $22.4 E/\theta^{2.5}$ foot-lamberts. Changes in foveal sensitivity immediately following the onset of a glaring illumination, and the effects of successive momentary stimuli were also studied.

J. W. T. WALSH

535.242.6

3540. Remarks on the Q term in the 3-colour photometry of Johnson and Morgan. M. GOLAY. *Arch. Sci. [Geneva]* **7**, No. 6, 491-3 (1954) In French.

535.31 : 535.81

3541. Transparent fibres for the transmission of optical images. H. H. HOPKINS AND N. S. KAPANY. *Optica Acta*, **1**, No. 4, 164-70 (Feb., 1955).

See Abstr. 3261 (1954). Further photometric and other studies of the optical properties of fibre bundles are described. The mechanism of transmission of light through these light channels is studied and experimentally verified. An account is given of a new machine for making bundles 75 cm long of fibres of smaller diameter, of the order of 25μ , and subsequently straightening the bundle so that all the fibres are of equal length. A study is made of different factors affecting the resolving power of such "static scanning devices" and measurements made on the resolution of periodic gratings are described. Some further applications of such fibres and fibre bundles are described.

A.

535.315 : 535.42

3542. On dependence of resolving power of prism, grating and reflecting echelon on stage of resolution and detecting instrument. OM P. SHARMA AND M. S. SODHA. *Indian J. Phys.*, **28**, No. 9, 437-40 (Sept., 1954).

Discusses the variation of the resolving power of a prism, grating and a reflecting echelon with the value chosen for I_{min}/I_{max} at limiting resolution, which is characteristic of the stage of resolution desired and the detecting instrument.

A.

535.317

3543. A family of perfect configuration lenses of revolution. G. TORALDO DI FRANCA. *Optica Acta*, **1**, No. 4, 157-63 (Feb., 1955).

A family of configuration lenses is described which collimate the rays from a point feed on a cone of varying aperture. The "lamp-shade," the Rinehart-Luneberg lens and the sphere are members of this family. A fourth member is worth noticing for its excellent scanning properties.

A.

535.317 : 518.5

3544. Use of electronic digital computers in optical design. G. BLACK. *Letter in Nature [London]* **175**, 164-5 (Jan. 22, 1955).

Electronic digital computers have been used for the tracing of rays through optical systems at high speeds. Large machines with auxiliary storage can accommodate enormous amounts of information so that extensive numerical investigations on lens systems may be carried out. The optical design problem is regarded as the minimization of a performance function with respect to constructional parameters of the lens system. Four principal machine minimization processes have been employed and are briefly described.

R. W. FISH

535.317.3

3545. On the achromatism of optical systems for more than two wavelengths. H. NAUMANN. *Abhandl. Braunsch. Wiss. Gesell.*, **6**, 107-12 (1954) In German.

Achromatism for any number k of wavelengths in a system of k thin lenses is possible when the partial dispersions of the k glasses of these lenses have no linear dependence on each other. Indeed this dependence is existent within the visible spectrum (Abbe). It is shown here that it is less actual with increasing distance of the wavelength considered from visible lines, esp. in infrared. Thus achromatism for more than two wavelengths is possible with normal glasses provided that no more than two of them are in the visible. But technical possibilities for the realization of such a multi-achromatic system are much better when natural or artificial crystals are used for one lens at least, or preferably for two. Glasses with shortened dispersion in blue ("short flints") are useful too, but need special consideration.

A.

535.317.4/.5

3546. Tables for the calculation of thin, cemented doublets, corrected for spherical aberration. A. BIOT. *Ann. Soc. Sci. Bruxelles*, **1**, **68**, No. 3, 167-74 (1954) In French.

These tables allow the three radii of a cemented doublet to be determined for a number of discrete values of refractive index and focal lengths of the

components, and for a series of object distances. A further table allows the rapid calculation of the residual spherical aberration when the lens is used at other conjugates.

R. W. FISH

535.322.4

3547. A linear refractometer. J. W. FORREST. Letter in *J. Opt. Soc. Amer.*, **45**, No. 2, 132-3 (Feb., 1955).

A critical-angle refractometer uses a high index glass prism to cover the range of index 1.33 to 1.47. A linear scale and micrometer drum are used and a computed error of the order of 0.00003 is achieved. The means of obtaining this order of accuracy is briefly discussed.

R. W. FISH

535.323 : 535.417

3548. Refractivity measurements on Canada balsam by interferometry. J. B. SAUNDERS. *J. Res. Nat. Bur. Stand.*, **53**, No. 6, 373-5 (Dec., 1954).

The index of refraction of three different samples of Canada balsam, each obtained from a different source, was measured for thirteen spectral lines in the visible range by means of the Fabry-Perot interferometer. This instrument permits absolute measurements when the method of coincidence (or method of exact fractions) is applied to fringes produced in thin films of the material being tested. High accuracy may be obtained by applying the method to fringes produced in films of successively increasing thickness.

A.

535.323 : 537.311.33

3549. Complex index of refraction of semiconducting surfaces. P. H. MILLER, JR. AND J. R. JOHNSON. *Physica*, **20**, No. 11, 1026-8 (Nov., 1954).

This paper reports a treatment of the reflection of polarized light at a semiconducting surface which has a complex index of refraction. Measurements of its components are briefly discussed.

P. T. LANDSBERG

535.325

3550. Measurement of the dispersion of gases in the interior of an infrared vibration-rotation band. F. LEGAY. *C.R. Acad. Sci. [Paris]* **240**, No. 2, 174-6 (Jan. 10, 1955) In French.

Describes an interferometer to be used in the infrared region up to 6μ . The first measurements were made on the fundamental vibration-rotation band at 3.4μ of HCl for which the distance between the lines is about 20 cm^{-1} . The dispersion between each line was measured, from which a variation of the index of about 90×10^{-6} was deduced. The dispersion curve agrees well with the theoretical one based on Kramer's formula.

J. JACOBS

535.33.03

3551. Comparison of the spectra produced by shock waves, flames and detonations. A. R. FAIRBAIRN AND A. G. GAYDON. Letter in *Nature [London]* **175**, 253-4 (Feb. 5, 1955).

Shock waves from bursting diaphragms will produce light flashes in certain pure fuel gases or fuel/argon mixtures. Despite difficulty with metallic impurities, study of the spectra of these flashes should help with interpretation of flame spectra. Preliminary results are reported for acetylene, ethyl nitrate, methane, methanol, etc. Shock-ignited and

spark-ignited explosions of fuel/oxygen mixtures show a difference in relative strength of CH and OH bands.

A. G. GAYDON

535.33.03

3552. Laboratory production of the Vegard-Kaplan bands. N. D. SAYERS, G. R. TAYLOR AND K. G. EMELÉUS. Letter in *Nature [London]* **175**, 254 (Feb. 5, 1955).

The $A^3\Sigma - X^1\Sigma$ bands of N_2 have been produced in various types of discharge tube at pressures between 1 cm and 160 cm Hg. Best results were obtained from a simple special tube at about 1 atm. using a Tesla discharge and external electrodes. The bands of this system which Bernard reported in the visible region could not be obtained.

A. G. GAYDON

535.33.07

3553. On filter photometers for the infrared. K. F. LUFT. *Rev. Opt.*, **33**, No. 10, 501-4 (Oct., 1954) In French.

Normal external filters are compared with internal filters, such as selective receivers, or emitters or absorbers of the same material as the test substance. One instrument with internal filter has a wedge of the test liquid moving across the beam, so that wavelengths absorbed are modulated and the receiver detects only these wavelengths; this method gives a high sensitivity and will detect $10^{-3}\%$ of cyclohexane in benzene.

G. F. LOTHIAN

535.33.07

3554. Experimental dispositions used on prism and grating spectrographs. P. BARCHWITZ. *Rev. Opt.*, **33**, No. 10, 518-20 (Oct., 1954) In French.

Several arrangements that have been constructed for use in series with a spectrometer are briefly described: (1) films of Se for production of plane polarized radiation by reflection or transmission; (2) mountings for measurement of diffuse and specular reflection; (3) a Michelson interferometer with diagonal plate of LiF with a $\lambda/4$ coating of Se; this is used to measure refraction anomalies within a vibration-rotation band.

G. F. LOTHIAN

535.33.07

3555. The instrumental line profile in prism spectrographs. H. MOSER. *Z. Phys.*, **140**, No. 1, 36-46 (1955) In German.

The profile of a line, which is a function of slit width, method of slit illumination, and aperture and absorption of the prisms, is measured photoelectrically for Cd and Hg sources for different slit widths, for coherent and incoherent slit illumination, and with bloomed and unbloomed optical components. With coherent illumination there are maxima and minima inside the geometrical image. Results are in accord with calculations of P. H. van Cittert [*Z. Phys.*, **65**, 547 (1930)].

G. F. LOTHIAN

535.33.07

3556. A light condenser for spectrographical purposes. K. TOISHI AND S. MIURA. Letter in *Nature [London]* **175**, 81-2 (Jan. 8, 1955); *J. Sci. Res. Inst. [Tokyo]* **48**, 149-53 (Sept., 1954).

A light condenser, acting upon the principle of superposition, is described for use with dispersed and transparent sources. It consists of two prisms, each

a combination of right-angled prism and a convex lens, which can be cemented directly on to the ends of an emission tube. Calculated intensifications of $12\times$ might be achieved but imperfections in the prism reduce this to $7\times$ in practice. The second paper contains sample records confirming the results.

R. W. FISH

535.33.07

3557. A compact monochromator employing rhombic, constant deviation prisms. J. W. GATES AND S. P. MIDDLETON. *J. sci. Instrum.*, **32**, No. 3, 113–15 (March, 1955).

This instrument was designed to isolate narrow spectral bands from discharge lamps and continuous sources more efficiently than is possible by using filters. Two 60° rhombic prisms are used to secure high dispersion for small physical size: the form of the prisms makes for compactness. A brief analysis of the problem of deciding on the prism shape is given, and the properties of a number of prisms are stated. The total deviation produced by the two rhombic prisms is 240° , so that the entrance and exit directions cross near the region of the entrance and exit apertures. These apertures are formed in a rotating turret, by means of which alternative pairs of apertures may quickly be brought into use. The diameter of each pair of apertures is twice the diameter of the next smaller aperture in order to facilitate the repetition of photographic exposures. A.

535.33.07 : 537.312.5

3558. Note on the use of photoconducting cells in spectroscopy. M. MUNSCH. *Rev. Opt.*, No. 10, 497–501 (Oct., 1954) In French.

Cells of PbS, PbSe and PbTe have been made. Sensitivity variation with wavelength of radiation and frequency of chopping are plotted for temperatures down to 23°K , together with signal to noise characteristics for different amplifier characteristics. Transmission curves are given for "Duran" glass which is satisfactory for a window nearly to 5μ . G. F. LOTHIAN

535.33.07

3559. Remarks on infrared spectrographs and their use. J. LECOMTE. *Rev. Opt.*, **33**, No. 11, 570–6 (Nov., 1954) In French.

A resolution of 3 cm^{-1} is sufficient for work on solids and liquids. $d\mu/d\lambda$, λ curves for various prism materials are given to assist in choice of prism for a given problem. Gratings are necessary in the very near infrared. Absorption curves measured under different resolutions are shown. G. F. LOTHIAN

535.33.07

3560. Grating spectrometer for the far infrared. A. HADNI. *Rev. Opt.*, **33**, No. 11, 576–84 (Nov., 1954) In French.

Describes an instrument with blazed grating of 14 lines per mm. Stray radiation is removed by (1) use of a depolished mirror; (2) chopping the beam with a sector having alternate apertures clear and covered with KBr, so that short λ 's are unmodulated and undetected by the tuned thermopile amplifier; (3) use of a Christiansen-type filter. The spectrum of monomethylamine has been investigated for $\lambda = 30 - 42\mu$, and is reproduced with resolution $\approx 0.7\text{ cm}^{-1}$. G. F. LOTHIAN

G. F. LOTHIAN

535.331

3561. On the hyperfine structure of ytterbium. K. KREBS AND H. NELKOWSKI. *Ann. Phys. [Leipzig]* **15**, No. 2, 124–34 (1954) In German.

The hyperfine structure of the Yb line $\lambda 6489\text{ \AA}$ is investigated spectroscopically. The splitting and intensities confirm the nuclear spin $I = 5/2$, which does not fit in with the simple shell model picture.

G. E. BROWN

535.331

3562. Analysis of the arc spectrum of lutetium. P. F. A. KLINKENBERG. *Physica*, **21**, No. 1, 53–62 (Jan., 1955).

The most important electron configurations in Lu I have been identified, and practically all strong lines have been classified. A list of levels (51) and a table of all classified lines (124) are given. The ionization potential is found to be 6.15 V . A.

535.331

3563. Extension of the arc spectra of palladium and platinum (6500 to 12 000 \AA). K. G. KESSLER, W. F. MEGGERS AND C. E. MOORE. *J. Res. Nat. Bur. Stand.*, **53**, No. 4, 225–8 (Oct., 1954).

These spectra have been reinvestigated photographically in the red and infrared, and extended approximately 2000 angstroms beyond the former limit of observation. The spectra were excited in conventional d.c. arcs between pure-metal electrodes and recorded by modern sensitized emulsions with the aid of diffraction gratings of 640 cm radius. Improved wavelength values and intensity estimates are given for 63 Pd I lines between 6508.42 and $11556.27\text{ \AA}$, and for 74 Pd I lines between 6648.32 and $10757.78\text{ \AA}$. All of the observed Pd I lines have been explained as transitions between known atomic energy levels, but only 42 of the 74 Pd I lines can be explained in like manner. It is concluded that further progress in the structural analysis of the Pt I spectrum is dependent on making an improved description in the visible and ultraviolet. A.

535.331 : 538.615

3564. Zeeman effects in the spectrum of plutonium. P. M. GRIFFIN AND J. R. McNALLY, JR. Letter in *J. Opt. Soc. Amer.*, **45**, No. 1, 63 (Jan., 1955).

Of over 200 Zeeman patterns, many reveal J values of $\frac{1}{2}$, $\frac{3}{2}$ or $\frac{5}{2}$. G. F. LOTHIAN

535.333

3565. On the height of the excited electronic states of CaO, SrO and BaO. A. LAGERQVIST AND L. HULDT. *Ark. Fys.*, **8**, Paper 41, 427–32 (1954) In German.

The variation with temperature of the intensity of bands excited in acetylene-air flames has been used to find the excitation energy of the electronic states. The flame temperature, measured by Na line reversal, was varied by altering the gas composition. The lowest known states, $X'^1\Sigma$, of CaO and SrO are found to lie at about 16500 and 13500 cm^{-1} respectively above the true ground states. The lowest known state of BaO, $X'^1\Sigma$, proves, however, to be the ground state. See also abstract following. R. F. BARROW

535.333

3566. The ultra-violet band system of strontium oxide. A. LAGERQVIST AND G. ALMKVIST. *Ark. Fys.*, **8**, Paper 47, 481–8 (1954) In German.

The rotational analyses of six bands of the system

$C^1\Sigma - X'^1\Sigma$ have been made. Constants for the upper state (cm^{-1}) are: $\nu_{0,0} = 28\,546.4$, $\omega_e = 480.2$, $x_e\omega_e \sim 2.6$, $B_e = 0.2742$, $\alpha_e = 0.0021$. Evidence for at least four states perturbing $C^1\Sigma$ has been found. The lower state is also the lower state of the blue and infrared systems. See also Abstr. 6466 (1954).

R. F. BARROW

535.333

3567. Term schemes of CaO, SrO and BaO. L. HULT AND A. LAGERQVIST. *Ark. Fys.*, **9**, Paper 13, 227-8 (1955) In German.

New experiments with $\text{H}_2\text{-O}_2$ flames at $2300 < T < 2750^\circ\text{K}$ are reported (see two preceding abstracts).

R. F. BARROW

535.333 : 539.132

3568. The infra-red spectrum and structure of boric acid. D. E. BETHELL AND N. SHEPPARD. *Trans Faraday Soc.*, **51**, Pt 1, 9-15 (Jan., 1955).

The infrared spectra of B(OH)_3 , both as a polycrystalline mull and in the form of a single crystal, have been studied between $3\,600$ and 500 cm^{-1} . With the help of the infrared spectrum of the corresponding deuterated molecule, B(OD)_3 , an assignment of the observed absorption bands has been given in terms of the fundamental vibration frequencies of the molecule. Previously published Raman spectra of boric acid have also been interpreted, and both types of spectroscopic data are shown to be consistent with the slightly distorted C_{3h} crystal site symmetry of the molecule as determined by X-ray methods.

A.

535.333

3569. Vibration-rotation bands of deuterium cyanide. P. B. CHECKLAND AND H. W. THOMPSON. *Trans Faraday Soc.*, **51**, Pt 1, 1-8 (Jan., 1955).

The rotational fine structure of a number of vibrational absorption bands of deuterium cyanide has been measured with high resolving power. An analysis has been made for the three fundamental bands ν_1 , ν_2 and ν_3 , for the overtone $2\nu_2$, and for the "hot" transition ($\nu_3 + \nu_2 - \nu_2$). The rotational constants B obtained lead to the following values: $\alpha_1 = +0.0066$, $\alpha_2 = -0.00415$, $\alpha_3 = +0.0104$ and $B_e = 1.2121\text{ cm}^{-1}$. There is good agreement with the values recently suggested by Douglas and Sharma except for α_1 , and it is suggested that some vibrational interaction may account for this. The results are consistent with values for the l -doubling coefficients $q_{010} = 0.0062$ and $q_{011} = 0.0078$.

A.

535.333

3570. The deuterium-sulfide band at 4590 cm^{-1} . H. C. ALLEN, JR., R. E. NAYLOR AND E. K. PLYLER. *J. Res. Nat. Bur. Stand.*, **53**, No. 5, 321-3 (Nov., 1954).

The absorption has been observed and measured under high resolution in the region from 4513 cm^{-1} to 4675 cm^{-1} . The rotational structure has been analysed through the use of published energy and line-strength tables for the rigid asymmetric rotor. A classical centrifugal-distortion correction was applied to the rigid energy levels. The absorption is attributed to the vibrational band having an excited state with the quantum number $(n_1, n_2, n_3) = (1, 1, 1)$. The inertial parameters giving the best fit to the observed absorption are:

Ground state: $A = 5.473\text{ cm}^{-1}$, $B = 4.490$, $C = 2.444$
Excited state: $A = 5.465\text{ cm}^{-1}$, $B = 4.482$, $C = 2.383$

Using the ground-state inertial constants, the D-S distance is calculated to be $1.345\text{ \AA}$, and the D-S-D angle $92^\circ 16'$, in excellent agreement with similar structural parameters determined for hydrogen sulphide from infrared studies.

A.

535.333

3571. The vibration-rotation spectrum of silyl iodide. R. N. DIXON AND N. SHEPPARD. Letter in *J. chem. Phys.*, **23**, No. 1, 215-16 (Jan., 1955).

The infrared spectrum of gaseous silyl iodide was taken in the region $2\text{-}20\mu$. As it hydrolyzes easily, care was taken to eliminate the strong bands of silyl ether. All observed overtones and combination bands were assigned. If the Si-H distance is taken to be $1.48\text{ \AA}$, the HSiH angle and the Si-I distance can be calculated ($109^\circ 54'$ and $2.45\text{ \AA}$ respectively).

A. J. TAYLOR

535.333

3572. The vibrational spectrum of methyl nitrate. J. C. D. BRAND AND T. M. CAWTHON. *J. Amer. Chem. Soc.*, **77**, No. 2, 319-23 (Jan. 20, 1955).

The infrared absorption in the vapour and liquid phase has been measured in the range $2\text{-}15\mu$ and frequencies have been assigned to all the fundamental vibrations except the two torsional modes. The characteristic frequencies of the $-\text{ONO}_2$ group are at 1672 , 1287 , 854 , 759 , 657 and 578 cm^{-1} . Comparison of the statistical and thermal entropies indicates that the barriers hindering internal rotation are small, and the infrared band contours and Raman depolarization factors are interpreted assuming free rotation about the O-N bond.

A.

535.337 : 537.228.5

3573. Theory of the Stark effect in a non-uniform field. II. Case of the hydrogen atom. R. CAYREL. *C.R. Acad. Sci. [Paris]* **240**, No. 6, 603-5 (Feb. 7, 1955) In French.

The perturbation calculation of Pt I [Abstr. 2576 (1955)] cannot be applied to the case of hydrogen because of the degeneracy of the energy levels. An expression is given for the perturbation of the hydrogen energy levels up to terms of the second order. It is suggested that the asymmetrical line shifts predicted could be observed in the profiles of the Balmer lines of A-type stars.

J. HUGHES

535.338.334

3574. Statistical theory of the effect of pressure on spectral rays. R. BERGEON AND B. VODAR. *C.R. Acad. Sci. [Paris]* **240**, No. 2, 172-4 (Jan. 10, 1955) In French.

A comparison with experimental results of the theory given earlier [Abstr. 10030 (1954)] limited to the perturbation of the D doublet of Na. For high pressures the theory predicts too small an enlargement. A comparison of the profiles as function of reduced frequencies shows agreement only for high frequencies; for lower frequencies the theoretical distribution falls too rapidly.

J. JACOBS

535.34

3575. Spectrophotometry in the infrared; its importance in physics and chemistry. J. LECOMTE. *Rev. Opt.*, **33**, No. 11, 553-66 (Nov., 1954) In French.

A review. Gives absorption curves of various

hydrocarbons, in the range up to 16μ , and a chart of the absorption bands of various groups in a number of compounds. Also shows absorption curves of powdered CuSO_4 —anhydrous, $1\text{H}_2\text{O}$ and $5\text{H}_2\text{O}$ —for $3\text{--}15\mu$.

G. F. LOTHIAN

535.343

3576. The pure rotational spectra of DBr, HI, and DI in the spectral region between 45 and 170 microns. E. D. PALIK. Letter in *J. chem. Phys.*, **23**, No. 1, 217–18 (Jan., 1955).

These spectra were taken at gas pressures between 20 and 50 cm Hg. In the DBr and DI spectra lines belonging to HBr and HI appeared. This indicated the presence of some hydrogen. The frequencies found are compared with those calculated. Rotational and centrifugal stretching constants were calculated. These agree well with values found from other data.

A. J. TAYLOR

535.343

3577. Pure rotational absorption spectrum of hydrogen. J. A. A. KETELAAR, J. P. COLPA AND F. N. HOOGE. Letter in *J. chem. Phys.*, **23**, No. 2, 413–14 (Feb., 1955).

Rotational lines have been observed at 814 and 1034 cm^{-1} at about 100 atmospheres. G. F. LOTHIAN

535.343

3578. Study of the absorption lines of the "green series" of copper oxide Cu_2O at very low temperatures. S. NIKITINE, R. REISS AND G. PERNY. *C.R. Acad. Sci. [Paris]* **240**, No. 5, 505–7 (Jan. 31, 1955) In French.

At 4°K , lines are found at 5468, 5417 and 5402 Å , fitting a Rydberg type formula. The lines shift $\sim 100\text{ Å}$ to longer wavelengths at 196°K .

G. F. LOTHIAN

535.343 : 536.48

3579. Study of the spectrum of absorption rays of PbI_2 at very low temperatures. S. NIKITINE AND G. PERNY. *C.R. Acad. Sci. [Paris]* **240**, No. 1, 64–5 (Jan. 3, 1955) In French.

At high temperature the spectrum of PbI_2 shows a weak band near the green with a maximum near 4945 Å . At the temperature of boiling nitrogen this band is narrower and much more intense; at lower temperatures (liquid He) the band becomes a line and a few more lines appear with it. These are investigated. They do not fit in a hydrogenlike series, unless one considers the first line as λ_2 , λ_1 being invisible. It is suggested that this series is due to the exciton. The exciton Rydberg constant is calculated.

A. J. TAYLOR

535.343

3580. Measurement of the ammonia band at 1.98μ . C. HAEUSLER. *C.R. Acad. Sci. [Paris]* **240**, No. 5, 507–8 (Jan. 31, 1955) In French.

Wave-numbers of 27 lines are given between 4927 and 5134 cm^{-1} to a precision of 0.1 cm^{-1} . It is suggested that the band is a multiple combination band: $\nu_1 + \nu_4$, $\nu_3 + 2\nu_2$ and $\nu_3 + \nu_4$. G. F. LOTHIAN

535.343

3581. Absorption spectra of lanthanide and actinide ions. C. K. JØRGENSEN. Letter in *J. chem. Phys.*, **23**, No. 2, 399–400 (Feb., 1955).

A numerical error in Satten's report on the neo-

dymium spectrum [Abstr. 4004 (1953)] is pointed out, and conclusions are drawn on the assignment of band groups. It is questioned if the electrostatic interaction is proportional to the atomic number minus a large shielding constant, the use of which assumption was made in previous reports on NpO_2^+ and PuO_2^{++} . The absorption spectra of actinide ions can be used for the evaluation of energy differences between 5f- and 6d-electrons. This is explained. A. J. TAYLOR

535.343

3582. Reply to Jørgensen's letter, absorption spectra of lanthanite [lanthanide] and actinide ions. R. A. SATTEN. Letter in *J. chem. Phys.*, **23**, No. 2, 400 (Feb., 1955).

See preceding abstract. The error pointed out by Jørgensen is confirmed, although the ratio was calculated correctly. No conclusion of the paper is affected. Values of F_R ratios were chosen to agree with previous assignments, though some of the values were somewhat large, but an adjustment could not be done in a unique way. The F_4/F_2 ratio will not equal the limit value, as assumed by Jørgensen, as this would imply that the square of the radial part of the 4f one electron wave-function is a δ function.

A. J. TAYLOR

535.343 : 535.372

3583. Relation of absorption and luminescence spectra of $\text{ZnS}:\text{Cu}$ phosphors to concentration of copper. M. N. ALENTSEV AND A. A. CHEREPNEV. *Zh. eksper. teor. Fiz.*, **26**, No. 4, 473–8 (1954) In Russian.

Investigation for series of different concentrations. Examination of results shows that in spite of the report of a number of observers that the blue luminescence appears in $\text{ZnS}:\text{Cu}$ with large Cu concentrations it is in fact due to pure ZnS centres and not to Cu centres.

J. EWLES

535.343 : 535.375.54

3584. Relation between the infrared spectrum and the Raman spectrum of crystals. Variations of frequency with the incidence in the infrared spectrum of sodium nitrate. J. A. A. KETELAAR, C. HAAS AND J. FAHRENFORT. *Physica*, **20**, No. 12, 1259–65 (Dec., 1954) In French.

A theoretical equation is derived for the reflecting power of uniaxial crystals for infrared radiation. Verification is made by measurement of the reflection spectra of NaNO_3 crystals for infrared radiation incident at angles of 0° , 27° , 45° , 64° and 90° .

G. I. W. LLEWELYN

535.343 : 535.372

3585. Study of the absorption and fluorescence of some organic molecules in crystalline media. P. PESTEL. *Ann. Phys. [Paris]* **10**, 128–84 (Jan.–Feb., 1955) In French.

An experimental study is made over a wide temperature range down to 2°K of the spectra of naphthalene, acenaphthene, diphenyl, anthracene, stilbene and tetraphenylbutadiene in the pure state and for such materials as impurities in another crystal lattice. Special attention is given to polarization in absorption and emission spectra. Results enable solute molecule orientation to be estimated.

G. F. J. GARLICK

535.343

3586. Anomalous infrared intensity in ethylene. D. F. EGGERS, JR. Letter in *J. chem. Phys.*, **23**, No. 1, 221-2 (Jan., 1955).

The three bending vibrations ν_7 , ν_{10} and ν_{12} of ethylene, at 949, 810 and 1444 cm^{-1} respectively, do not show comparable intensities. Band moments calculated from these have values of $0.8D$ and $0.4D$ for ν_7 and ν_{12} . The ν_{10} vibration has a very low force constant. On the basis that the p orbitals remain perpendicular during vibration, the moments along the C-H bonds are calculated to be $1.36D$. The calculated discrepancy is twice the observed, but correlation and polarization have been neglected. Comparison between different compounds predicts effects which are experimentally verified. A. J. TAYLOR

535.343 : 539.133

3587. Infrared investigation of the benzene-chlorine molecular complex. J. COLLIN AND L. D'OR. Letter in *J. chem. Phys.*, **23**, No. 2, 397 (Feb., 1955).

Mulliken's charge transfer theory of molecular complexes (see abstract following) interprets the properties of these complexes adequately, though experimental data give no indication as to the geometric arrangement of the complex. The infrared absorption of benzene-halogen complexes was studied. The chlorine solution in benzene showed a shift from 557 cm^{-1} (for free Cl_2) to 526 cm^{-1} . For iodine the region of the fundamental frequency was not reached, and the bromine solutions were not favourable because of water vapour absorption. The Cl_2 molecule axis is not parallel to the benzene plane, and must be unsymmetrically placed. The broadness of the band could be caused by thermal motion. A. J. TAYLOR

535.343 : 539.133

3588. Molecular compounds and their spectra. V. Orientation in molecular complexes. R. S. MULLIKEN. Letter in *J. chem. Phys.*, **23**, No. 2, 397-8 (Feb., 1955).

The Cl-Cl frequency, which is observed in solutions of Cl_2 in benzene, is shifted from 557 cm^{-1} for free Cl_2 to 526 cm^{-1} . This is strong evidence in favour of the formation of a benzene- Cl_2 loose charge transfer complex in which the accepted electron goes into an anti-bonding MO of the acceptor. The Cl_2 frequency is strongly infrared active, which is to be expected if the Cl_2 molecule is asymmetrically oriented. This suggests an oblique model or an asymmetrical model. Some considerations regarding this charge transfer complex are discussed. See also preceding abstract. A. J. TAYLOR

535.343 : 578.088.5

3589. Biological applications of infrared spectroscopy. H. LENORMANT. *Rev. Opt.*, **33**, No. 11, 566-70 (Nov., 1954) In French.

A review, particularly of work on the structure of steroids. Microspectroscopy, using only $1\ \mu$ of substance, is useful. Proteins, etc. that are destroyed on drying, can be usefully measured in D_2O , which is transparent in the range $2000\text{--}1500\text{ cm}^{-1}$. G. F. LOTHIAN

535.345

3590. Glasses transparent in the infrared. G.

DEWULF. *Rev. Opt.*, **33**, No. 10, 513-18 (Oct., 1954) In French.

Curves are given for transmission through windows of: Se, transparent to $20\ \mu$; As_2S_3 , transparent to $12\ \mu$; As_2Se_3 , transparent to $>14\ \mu$; As_2S_5 , transparent to $11\ \mu$; $\text{As}_2\text{S}_3\text{Se}_2$ and $\text{As}_2\text{S}_2\text{Se}_3$, both transparent to $11\ \mu$. G. F. LOTHIAN

535.345

3591. Absorption of radiant energy by solid particles in suspension. J. E. STEWART. *J. Res. Nat. Bur. Stand.*, **54**, No. 1, 41-6 (Jan., 1955).

A simple theory is developed to describe the absorption of radiant energy by particles suspended in a transparent medium and also by an absorbing medium containing transparent suspended particles. It is found that in both cases transmittance increases as particle size increases. Apparent deviations from Beer's law and other effects that might introduce difficulties in experimental work are discussed. A.

535.345 : 539.23

3592. Infrared absorption of thin metal films at non-normal incidence. C. HILSUM. Letter in *J. Opt. Soc. Amer.*, **45**, No. 2, 135-6 (Feb., 1955).

A generalized formula extended to include all angles of incidence is given for the infrared absorption in a metal film supported on a dielectric. Absorption curves for both polarized and unpolarized radiation are illustrated. In unpolarized light a case is plotted in which the absorption is almost independent of angle of incidence up to 45° . S. TOLANSKY

535.345 : 548.7

3593. Properties of single cadmium sulfide crystals. D. C. REYNOLDS, S. J. CZYZAK, R. C. ALLEN AND C. C. REYNOLDS. Letter in *J. Opt. Soc. Amer.*, **45**, No. 2, 136-8 (Feb., 1955).

Crystals of CdS of average size $8 \times 4 \times 5\text{ mm}$ were grown with various amounts of oxygen impurity up to 2% and their properties investigated. Oxygen affects the optical absorption edge structure and the spectral response for photoconductivity. The spectral response is different when measured by short to long wavelength traverse from that for long to short wavelength traverse. It is held that oxygen predominantly affects carrier mobility rather than carrier concentration. G. F. J. GARLICK

535.347 : 535.345

3594. On the pleochroism of amethyst quartz and its absorption spectra. S. PANCHARATNAM. *Proc. Indian Acad. Sci. A*, **40**, No. 5, 196-210 + ii pp. figs. (Nov., 1954).

Amethyst is optically biaxial, and does not conform to the trigonal symmetry of colourless quartz, though the c -axis appears as the acute bisectrix in its biaxial figure. The pleochroic and biaxial properties taken together conform only to a symmetry of the monoclinic class, the axis of symmetry being coincident with one of the electrical axes of the colourless quartz in which it appears. For vibrations along this axis, the colour of the transmitted light is light orange (absorption maximum near $5000\ \text{\AA}$); while for the two vibrations in the perpendicular plane which make approximately 45° on either side of the c -axis, the colours are respectively, blue (absorption maximum near $5750\ \text{\AA}$), and a deep reddish-purple (absorption maximum

near 5250 Å). Which of the α -axes of quartz is the symmetry axis of amethyst is determined—in relation to the particular rhombohedral face with which the colour-sector is associated—by the right- or left-handedness of the segment; while the disposition of the other two colour axes with reference to the associated face depends on whether this belongs to the primary or the secondary rhombohedron. Hence, the presence of any twinning naturally complicates the pleochroism. Photographs are reproduced illustrating (a) the absorption spectra for the trichroic colours; (b) the idiophanous and biaxial figures seen through dense sectors in convergent light (the optic axial plane containing the symmetry axis); and (c) the anomalous dispersion of the birefringence. A.

535.371

3595. Yield of anti-Stokes fluorescence of dye solutions. A. JABŁŃSKI. *Acta phys. Polon.*, **13**, No. 4, 239–42 (1954).

A new explanation is suggested of the much discussed phenomenon of the abrupt drop in the anti-Stokes region of the curve representing the quantum yield of fluorescence of dye solutions as a function of the wavelength of the exciting light. The author believes that this drop is due to the long wavelength tail of the absorption band of non-luminescent dimers superimposed on that of (luminescent) monomers and even extending beyond it. A.

535.371

3596. On the decay time of fluorescence of acridine orange. A. SCHMILLEN. *Z. Naturforsch.*, **9a**, No. 12, 1036–9 (Dec., 1954) In German.

Measurements of decay time are made for the dye in aqueous and alcoholic solution and for the dye base in benzene. The decay time of the base is 5.5×10^{-9} sec and independent of concentration range used. Aqueous and alcoholic solutions show a critical concentration the decay time being constant below this (2.4×10^{-9} and 4.5×10^{-9} sec respectively). Above this the decay time rises rapidly with dye concentration which is attributed to association between the dye ions. G. F. J. GARLICK

535.371

3597. The development of luminescence since the 1938 Oxford Conference. S. T. HENDERSON. *Brit. J. appl. Phys., Suppl. No. 4* [Luminescence] S 1–S 4 (1955).

A review of the state of knowledge of inorganic phosphors in 1938, and of the main practical and theoretical developments which have occurred up to the present time. 29 refs. A.

535.371

3598. Some unsolved problems in luminescence. J. W. STRANGE. *Brit. J. appl. Phys., Suppl. No. 4* [Luminescence] S 4–S 5 (1955).

535.371

3599. Applied cathodoluminescence. C. G. A. HILL. *Brit. J. appl. Phys., Suppl. No. 4* [Luminescence] S 6–S 11 (1955).

The classes of phosphor in commercial use at the present time comprise the zinc and cadmium sulphides, the manganese-activated silicates, titanium- and cerium-activated calcium magnesium silicates, the manganese-activated fluorides and zinc oxide. Each is

limited to particular operating conditions. Attempts to produce a phosphor emitting white light with an efficiency comparable with that of a mixture of blue and yellow emitting sulphides have met with only partial success. The intrinsic efficiency of cathodoluminescent materials increases with the bombarding voltage up to about 25 kV but decreases in all cases at very high intensities of excitation. The maximum efficiencies so far observed are about 23% for zinc sulphide phosphors and about 8% for other types, or between $\frac{1}{3}$ and $\frac{1}{2}$ of the maximum efficiencies of the same phosphors under ultraviolet excitation. Recent work on single crystals, showing the limitations of the Thomson–Whiddington law, is relevant to the question of efficiency. Practical cathode-ray tube screens exhibit much lower luminous efficiencies chiefly owing to the fact that they are viewed from the opposite side from that excited. Other losses arise from the sensitivity of the phosphor to the manufacturing processes. Little is known of the mechanism by which the efficiency of a screen falls during life, but it appears that electron bombardment creates new centres of various kinds; for example, a new sensitivity to ultraviolet excitation is produced in the fluoride phosphors. A.

535.371

3600. Preparation and characteristics of calcium halophosphates. M. DOHERTY AND W. HARRISON. *Brit. J. appl. Phys., Suppl. No. 4* [Luminescence] S 11–S 18 (1955).

After a brief survey of the characteristics of the important antimony-manganese activated calcium halophosphates, a more detailed description is given of the dry and wet syntheses. The colour characteristics and the theoretical and attained efficiencies are discussed with reference to three halophosphates, the light blue, the daylight and the warm white. Maintenance of light output of fluorescent lamps, and the improvement of lamp colour by admixture with other phosphors, are also considered. A.

535.371

3601. The investigation of new phosphors, with particular reference to the pyrophosphates. P. W. RANBY, D. H. MASH AND S. T. HENDERSON. *Brit. J. appl. Phys., Suppl. No. 4* [Luminescence] S 18–S 25 (1955).

There is a continuing demand for new phosphors in the fluorescent lamp industry and the initial stages of the search for suitable materials are essentially of a chemical nature. Some of the techniques used in this work are illustrated by reference to a large group of alkaline earth pyrophosphate phosphors recently developed. These materials utilize Sn^{2+} or Ce^{4+} as primary activator and manganese as secondary activator, and are of considerable potential application. Physical methods of analysis have proved indispensable in providing an understanding of this pyrophosphate system. By means of X-ray and differential thermal analysis the various crystal structures of the pure pyrophosphates have been studied, and the conditions for the existence of the different forms established. Crystal data for the more important structures are given. The relationships between the main peaks of the emission bands, crystal structures and activators are discussed. A

detailed study of such systems, in which interchange of matrix metal, well-defined crystal changes and different activators produce marked changes in the fluorescence, may prove to be of importance in developing a useful theory of luminescence in activated inorganic solids.

A.

535.371

3602. The luminescent properties and crystal structure of some new phosphor systems. A. H. McKEAG AND E. G. STEWARD. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 26-S 31 (1955).

New phosphor systems are described which illustrate the importance of combining the study of fluorescent properties of new systems with the results of X-ray analysis. The systems described include a range of tin-activated pyro- and tetraphosphates of strontium and barium, and a group of manganese or cerium-manganese-activated silicates containing lithium. The preparation and fluorescent properties of these phosphors are discussed. X-ray methods have been used to identify the phases responsible for the various phosphors and a number of new phases including polymorphic forms, have been found. X-ray powder diffraction data are included. The practical importance of the new phosphors is discussed with reference to fluorescent lamps in general. Emphasis is placed on the colour correction of high-pressure mercury vapour lamps by certain members of the complex lithium-containing silicate phosphors.

A.

535.371

3603. Some unusual phosphors. S. ROTHCHILD. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 32-S 33 (1955).

An account is given of the preparation and properties of some phosphors excited by ultraviolet radiation of short wavelength, namely boron phosphate activated by thallium, and some arsenate analogues of the halophosphates; also of "self-activated" vanadates excited by ultraviolet radiation of long wavelength.

A.

535.371

3604. Electroluminescence of zinc sulphide phosphors. K. H. BUTLER AND J. F. WAYMOUTH. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 33-S 38 (1955).

A brief historical survey is given of the effects of electric fields on phosphors, and of recent work leading to the development of a practical light source. The phosphor preparation is described, and details of dielectric requirements, lamp construction and optical and electrical characteristics of the lamps discussed. Reference is made to work on the effects of pulsed d.c. excitation, and on the microscopical examination of electroluminescent single crystals. Current theories of the mechanism of electroluminescence are briefly discussed.

A.

535.371

3605. The mechanism of electroluminescence of zinc sulphide. W. W. PIPER AND F. E. WILLIAMS. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 39-S 49 (1955).

The impact excitation mechanism of electroluminescence is formulated and applied to the electroluminescence of ZnS. Cu crystals. A barrier similar to the

Mott-Schottky exhaustion barrier exists in the crystal at each electrode. Quantum mechanical tunnelling through the barrier yields excitation in phase with the applied alternating voltage, as well as d.c. electroluminescence. Both shallow and deep donors in the exhaustion layer are prerequisite for excitation out of phase with the applied alternating voltage, and a continuous energy distribution of deep donors yields the experimental dependence on voltage of the intensity of the out of phase component of electroluminescence. Several donor distributions are theoretically analysed in detail. The conduction electrons which deviate from average behaviour by experiencing fewer collisions with lattice vibrations, thereby attaining high velocities with fields below breakdown values, probably are of importance to the mechanism. The actual excitation of the luminescence centre may be accomplished by capture of electron-hole pairs formed by impact ionization.

A.

535.371

3606. Brightness waveforms in electroluminescence. G. DESTRIAU. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 49-S 54 (1955).

The shape of the "brightness waves" in electroluminescence depends on many factors: field intensity, frequency and the direction in which the light output is observed. The shape also depends on the device used as electroluminescent condenser and, for some substances, the shape is slightly different according to the spectral region observed. In the Gudden and Pohl effect (momentary illumination) there is a similar appearance of the disturbances shown in electroluminescence. In the electro-extinctive effect the shape of the brightness waves changes quickly during the first second and then slowly for about ten seconds after the field is applied.

A.

535.371

3607. Electroluminescence of organic compounds. A. BERNANOSE. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 54-S 56 (1955).

Electroluminescence has been produced in organic fluorescent compounds. Adsorbates of such materials on cellulose films have been prepared which when dry and free from oxygen show phosphorescence. The films are mounted as the dielectric of a condenser having one transparent electrode and an alternating potential is applied. After these dielectric cells have been exposed to sunlight they show an electrophotoluminescence which quickly disappears leaving the normal electroluminescence. New emission bands in addition to the normal bands of luminescence emission are observed. Compounds investigated include gonacrin, brilliant acridine orange E and carbazole.

A.

535.371

3608. The physical chemistry of sulphide phosphors. F. A. KRÖGER. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 58-S 64 (1955).

In order to make possible a description of the formation of phosphors by the concepts of physical chemistry, simplification of the chemical composition of the system and the conditions of preparation is indispensable. For a particular case, namely, ZnS, it is shown how preparation under controlled conditions may lead to a knowledge of the microstructure

of the solid, and thence to an insight into the nature of the centres of luminescence and traps. It is shown that this knowledge is a necessary condition for the complete physico-chemical description of the formation of the phosphor in equilibrium with an atmosphere or a melt.

A.

535.371

3609. Physical measurements and the nature of the luminescent centre. J. H. SCHULMAN. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 64—S 69 (1955).

Important information concerning the nature of the luminescent centre may be derived from comparatively simple physical measurements. Comparison of the temperature dependences of luminescence efficiency and decay rate gives information about the location of dissipative transitions and permits the calculation of activation energies and frequency factors for these transitions in certain cases. Information concerning the interaction of activators with their environment, as in sensitized luminescence and concentration quenching, is also derivable from these measurements. From additional measurements of the low temperature absorption and emission-band peaks and widths and the bandwidth variation with temperature, the configuration co-ordinate curve of a centre can be derived experimentally. Information concerning energy transfer in non-photoconducting sensitized phosphors may be obtained from measurements of absorption (reflection) spectra or of quantum efficiency as a function of composition. Similar measurements can demonstrate the formation of pairs or higher aggregates of activators and lead to a determination of oscillator strength.

A.

535.371

3610. Energy transfers in the calcium halophosphate phosphors. G. R. FONDA. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 69—S 73 (1955).

Measurements have been made at temperatures of 87–475°K of the quantum output and efficiency of calcium fluorophosphate phosphors activated with variable concentrations of antimony and manganese. For antimony alone, the efficiency is greater and the temperature sensitivity is less when its concentration is so low that the luminous emission has a greater probability of arising from a primary, excited centre than from a centre which has received its excitation by successive transfer steps of resonance energy. Consideration of the relative probability of these two types of emission serves to explain the greater output of manganese emission with increase in the concentration of either antimony or manganese, as well as the lower temperature sensitivity of the manganese emission. Not only does immediate emission from the excited centre prove to be a more efficient process than emission which follows a resonance transfer, but the sensitized emission of manganese is found to be more efficient when it occurs as a direct transfer from a sensitizer to an activator centre than when it follows a succession of transfer steps.

A.

535.371

3611. Divalent manganese as a luminescent centre. C. C. KLINK. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 74—S 78 (1955).

Current information concerning the luminescence of

divalent manganese is reviewed. Recent experimental and theoretical investigations indicate that the excited state leading to emission has four of the 3d electrons with parallel spins and one anti-parallel, while the ground state has all electrons with parallel spins. Configuration co-ordinate curve calculations from experiment show that there is little lattice relaxation around the manganese ion after optical transitions. This has led to one explanation of the asymmetric emission-band characteristic of divalent manganese in terms of transitions to discrete vibrational levels of the ground state. Another widely proposed explanation is that there are various sub-bands in the emission spectrum coming from close-lying electronic states of the ion. Auxiliary experiments have thus far failed to decide between these views. In silicate-type phosphors both red and green emission bands arise from divalent manganese. Two explanations have been offered for these bands. One, the "cluster" theory, is that each band corresponds either to a single ion or cluster of ions. The other, the "co-ordination" theory, is that the colour is primarily dependent on the number of ions surrounding the activator. Recent experiments on the concentration dependence and magnetic properties of manganese-activated silicate phosphors tend to support the latter explanation.

A.

535.371

3612. Atomic configurations in luminescent centres. W. A. RUNCIMAN. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 78—S 85 (1955).

When the activator ions in a phosphor have a charge different from that of any ions in the host lattice, it is generally agreed that charge compensation must take place. A new theory of luminescent centres is proposed in which the compensation of charge, by lattice vacancies or by activator ions, is localized in the vicinity of the activator ions. This theory is primarily applicable to ionic crystals, and specific configurations of lowest energy can be deduced. These configurations are described in detail for alkaline-earth oxide, uranate and fluoride phosphors, and the vibrations of these centres are discussed. A number of original phosphors of theoretical interest, including CaO . Bi, Li; CaO . U, Li; CaO . U, Sm; and the uranates, are described and spectra are shown. Finally, necessary modifications of the present theories of sensitized luminescence and multiple-band emission are considered.

A.

535.371

3613. Absorption, emission and storage of energy in phosphors. G. F. J. GARLICK. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 85—S 90 (1955).

The characteristics of photoconducting phosphors of the sulphide class are reviewed in relation to the accepted energy band model for such phosphors. It is shown that the model is inadequate to explain the processes involved in the thermal and optical ejection of trapped electrons. Considerable evidence points to the coexistence of emission, trapping and "killer" systems in large centre complexes. Preliminary results of studies on single crystal specimens show that the dielectric changes shown by microcrystalline phosphors on excitation are associated with grain boundary effects rather than with trapping effects in the crystal

volume. Loss changes in single crystals agree with photocurrent values in d.c. fields. Preliminary measurements of long wavelength absorption bands associated with trapped electrons in excited cadmium sulphide crystals are reported. A.

535.371

3614. Luminescence and electrical conductivity of crystal phosphors. I. BROSER AND R. BROSER-WARMINSKY. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 90-S 94 (1955).

Using a general form of the energy band model for a crystal with a wide distribution of lattice defect levels, comprehensive equations are developed which relate the luminescence and photoconduction in crystal phosphors to excitation intensity, time and temperature for different physical conditions. These include steady state excitation, phosphorescence, photoconduction decay and continuous warming of the phosphor. Measurements on single crystals of ZnS and CdS show good agreement between the theory and experiment. A.

535.371

3615. Use of radioactive isotopes for research on inorganic phosphors. E. GRILLOT AND M. BANCIE-GRILLOT. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 95-S 96 (1955).

The radioactive tracers are of great interest for controlling the efficiency of purification of raw materials. Moreover, the action of thermal neutrons on inorganic phosphors may be used for microdeterminations, not only of activator elements such as copper, but also of halogens. A.

535.371

3616. Theory of activator systems in luminescent solids. F. E. WILLIAMS. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 97-S 102 (1955).

The theory of localized activator systems in ionic phosphors is reviewed. The monovalent thallium and divalent manganese activator systems are treated quantitatively in detail. The importance of the non-spherical symmetry of the electron distribution of excited Tl^+ and Mn^{2+} is emphasized. The excitation and emission spectra are evaluated both classically and quantum mechanically from the energies of the accessible atomic configurations of the activator system in the ground and emitting states, respectively. The origin of the fine structure of emission of the tetravalent manganese activator systems is discussed. Modifications in the theory are proposed for covalent luminescent solids such as the zinc sulphide phosphors. A.

535.371

3617. Excitation of phosphors by electrons. G. F. J. GARLICK. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 103-S 106 (1955).

An attempt is made to provide a sound basis for a quantitative theory of cathodoluminescence. Previous theories have neglected the marked scattering of primary electrons by elastic and inelastic collisions, and the effects of this on secondary emission and distribution of secondary electrons responsible for luminescence excitation in the phosphor. Particular attention is given to the detailed processes involved in penetration of the primary particles and to the

question of the ultimate limits of cathodoluminescence efficiencies. The latter are shown to be determined by the non-radiative energy transitions of thermal velocity secondary electrons. It appears that the theoretical limit has already been approached in practice. A.

535.371

3618. Nonlinearity in photoconducting phosphors. C. A. DUBOC. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 107-S 111 (1955).

The luminescence and photoconductivity of photoconducting phosphors are generally rather complicated non-linear functions of the exciting intensity, if recombination occurs competitively at two types of centres. Certain properties of several two-centre models have been discussed by earlier investigators, and one model has been examined in detail by Schön. This paper aims at a broader survey of the types of non-linear behaviour and of the generality of their occurrence with different models. A family of models is introduced which in a sense exhausts the simple possibilities for two-centre systems. In many cases, the essential features of more complex systems are adequately rendered by the simple models. A suitable method for analysing the models is presented and results are surveyed. Any model with excitation in the fundamental absorption band of the crystal can show emission proportional to the excitation intensity to the power γ over an extended range with $\gamma = 0, 1/2, 2/3, 1, 3/2, 2, \text{ or } \infty$. Superlinearity is favoured by excitation in the luminescence centres, and sublinearity by excitation in the competing centres. A wider variety of conductivity dependences is found, among which there are cases in which the conductivity decreases with increasing excitation. The results emphasize the great advantage of simultaneous electrical and optical observations on any such system. A.

535.371

3619. Some experimental results on electroluminescence. A. LUYCKX AND A. J. STOKKINK. *Brit. J. appl. Phys., Suppl. No. 4 [Luminescence]* S 57-S 58 (1955).

Results are presented on the relation between voltage and the logarithm of light output, which gives a linear plot for ZnS. Mn but not for ZnS. Cu. Irregularities in the brightness waveforms are attributed to imperfections in the applied sinusoidal potential. Work on the electroluminescence of zinc silicate, and on polarity effects, is also mentioned. A.

535.371

3620. Fluorescence transfer in condensed aromatic hydrocarbons. O. SIMPSON AND D. C. NORTHROP. *Physica*, 20, No. 11, 1122-5 (Nov., 1954).

The fluorescence of naphthalene, pentacene, perylene, anthracene, coronene, dinaphthopyrene, violanthrene, isoviolanthrene and ovalene, as solutes in anthracene with concentrations of 10^{-4} and 10^{-3} molar. Fluorescence transfer is observed in each case. Quenching effects are more noticeable for solute molecules of extended form. The semi-conduction of the systems approaches that of pure anthracene at high temperatures but is greater at lower temperatures, a typical exponential dependence on temperature being shown. G. F. J. GARLICK

535.371

3621. Polarization of fluorescence of diatomic gas molecules. E. LAFFITTE. *J. Phys. Radium*, **16**, No. 1, 66–71 (Jan., 1955) In French.

535.371

3622. Activations by anions in the oxy-acid phosphors. Y. KOTERA. Letter in *J. chem. Phys.*, **23**, No. 1, 219–20 (Jan., 1955).

535.371

3623. Contribution to the study of the luminescence of dyestuffs. E. LAFFITTE. *Ann. Phys. [Paris]* **10**, 71–127 (Jan.–Feb., 1955) In French.

A review of the knowledge of fluorescence in dyes dispersed in a medium is given together with experimental studies of the polarization of fluorescence of dyes in plastic media and their phosphorescence. An extended discussion of the collective electron model for the dye fluorescence is given. G. F. J. GARLICK

535.371

3624. Energy transfer in polystyrene-anthracene. F. H. KRENZ. *Trans Faraday Soc.*, **51**, Pt 2, 172–83 (Feb., 1955).

The solid polymer formed by thermally polymerizing styrene containing a small amount of dissolved anthracene shows the characteristic anthracene fluorescence when the polymer is excited by X- or γ -rays. It is shown that at concentrations of anthracene below $\sim 5 \times 10^{-4} M$ a transfer of excitation energy from polystyrene to anthracene occurs by the simple process of fluorescence and reabsorption. At these concentrations the efficiency with which polystyrene fluorescence is converted to anthracene fluorescence is not greater than 0.2. The efficiency increases at higher anthracene concentrations, where there is independent evidence that a compound is formed between anthracene and polystyrene. A different type of energy transfer is shown to occur at the higher concentrations which may be ascribed to intramolecular conversion of the excitation energy. A.

535.371

3625. The preparation of calcium halophosphate. W. L. WANMAKER, A. H. HOEKSTRA AND M. G. A. TAK. *Philips Res. Rep.*, **10**, No. 1, 11–38 (Feb., 1955).

535.371

3626. Optical properties of calcium meta-antimonate. J. JANIN AND R. BERNARD. *C.R. Acad. Sci. [Paris]* **240**, No. 6, 614–15 (Feb. 7, 1955) In French.

$CaSb_2O_6$ activated by Mn shows an emission band at 5200 Å with excitation bands at 2300 and 2800 Å. Pb activation gives phosphorescence with spectral maximum at 4400 the 2800 Å excitation band being predominant. G. F. J. GARLICK

535.371 : 537.312.5

3627. Photoconduction and luminescence in crystals of the ZnS group. M. SCHÖN. *Physica*, **20**, No. 11, 930–49 (Nov., 1954) In German.

Reaction equations for excitation of a ZnS-type phosphor are developed assuming simple emission centres with energy levels below and trapping centres with levels above the Fermi limit. Solutions for variation of luminescence and photocurrent with excitation intensity are given for the stationary state. Kinetics of “build up” and decay are also treated.

G. F. J. GARLICK

535.371 : 539.13

3628. An experimental study of the transfer of energy of excitation between unlike molecules in liquid solutions. E. J. BOWEN AND R. LIVINGSTON. *J. Amer. Chem. Soc.*, **76**, No. 24, 6300–4 (Dec. 20, 1954).

In solutions containing two fluorescent solutes, where the emission spectrum of the first (A) overlaps the absorption spectrum of the second (B), the fluorescence of A is quenched, and the fluorescence of B is sensitized. The intensities of the fluorescence of each component were measured for the following pairs of aromatic hydrocarbons: chloroanthracene-perylene, chloroanthracene-rubrene and cyanoanthracene-rubrene. The transfer of energy of excitation between these compounds is much more efficient than can be accounted for by a process of emission and reabsorption. The data are consistent with the postulate that the non-radiative transfer of energy is a bimolecular interaction between an excited molecule of A and a normal molecule of B. The rate of this interaction is not determined by diffusion, being apparently independent of the viscosity of the solvent and (even in benzene) at least ten-fold faster than a diffusion-controlled process. Furthermore, it is not due to the formation of dimers, as is demonstrated both by the nature of the concentration dependence of the fluorescence and by the validity of Beer's law when applied to the mixed solutions. A.

535.371 : 548.7

3629. Movement of conduction electrons in crystal luminescence. D. CURIE. *J. Phys. Radium*, **16**, No. 1, 77–8 (Jan., 1955) In French.

Assuming electron traps to be near luminescence centres the small amount of retrapping of thermally ejected electrons and the relatively large degree of retrapping of optically ejected electrons are explained by the low and high velocities respectively for the ejected electrons in the conduction band. The reaction kinetics cannot thus be clearly designated as mono- or bimolecular. G. F. J. GARLICK

535.372

3630. Analysis of the ultraviolet fluorescence spectra of I_2 molecule. C. V. NARAYANA RAO AND V. RAMAKRISHNA RAO. *Indian J. Phys.*, **28**, No. 9, 403–22 (Sept., 1954).

New and improved wavelength data on the fluorescence bands of iodine vapour excited by mercury lines is given. Wavelength data on McLennan bands is obtained from thallium spark excitation for the first time. A complete analysis of these fluorescence bands in the region 4738–1959 Å is presented. Four new electronic states in Mulliken's term scheme for I_2 molecule are identified. It is suggested that no resonance series are obtained in ultraviolet on excitation with mercury arc lines. A.

535.372

3631. The shape of the emission bands of luminescent solids. C. C. VLAM. *Brit. J. appl. Phys.*, **5**, No. 12, 443–6 (Dec., 1954).

Single emission bands of luminescent solids generally exhibit a bell-shaped form. Closer examination of emission curves of a simple nature demonstrates a very close Gaussian form, but only when energy is plotted as a function of frequency. More complex

emission curves can be very well described as a sum of Gaussian distribution functions. The experimentally determined shape of the emission profile is compared with theoretical emission curves, calculated from the configuration co-ordinate model. A.

535.372 : 535.375.5

3632. Intensity comparison of the Raman effect and fluorescence radiation. J. EISENBRAND. *Optik*, **11**, No. 12, 557–61 (1954) In German.

The combined Raman and fluorescence spectrum is photographed for an aqueous solution of a fluorescent dye at concentration 10^{-8} g/cm³, excited by $\lambda = 3650 \text{ \AA}$; the energy of the fluorescent light is ≈ 10 times that of the Raman line for water at $4171 \text{ \AA}$. Points of interest are: (1) From the known absorption of the dye, it follows that 0.0023% of the incident radiation goes into the Raman line. (2) The correct exposure for Raman lines may be found from a short exposure on a more concentrated solution. (3) The limiting sensitivity of fluorimetry may be set by this Raman intensity. G. F. LOTHIAN

535.375.5

3633. The structure of selenium tetrachloride in the solid and of tellurium tetrachloride in the liquid and the solid state. H. GERDING AND H. HOUTGRAAF. *Recueil Trav. chim. Pays-Bas*, **73**, No. 9–10, 737–47 (Sept.–Oct., 1954).

Raman spectra were obtained for SeCl_4 in the solid and for TeCl_4 in the solid and the liquid state. Polarization measurements were formed for the stronger Raman lines of liquid TeCl_4 . The four stronger Raman lines of SeCl_4 are very close in frequency to those of pyramidal AsCl_3 ; there is also a close analogy between the frequencies of the stronger Raman lines of TeCl_4 (both in the solid and in the liquid state) and those of antimony trichloride. These findings favour the assumption that solid SeCl_4 and TeCl_4 have to be written as $\text{SeCl}_3^+\text{Cl}^-$ and $\text{TeCl}_3^+\text{Cl}^-$ respectively, SeCl_3^+ being isosteric with AsCl_3 and TeCl_3^+ with SbCl_3 . Force constant and frequency calculations have been effected for the hypothetical SeCl_3^+ and TeCl_3^+ ions. The results support the above assumption. A.

535.375.5

3634. Investigation of the structure of the compounds $\text{TeCl}_4 \cdot \text{AlCl}_3$ and $\text{SeCl}_4 \cdot \text{AlCl}_3$ by means of the Raman effect. H. GERDING AND H. HOUTGRAAF. *Recueil Trav. chim. Pays-Bas*, **73**, No. 9–10, 759–70 (Sept.–Oct., 1954).

Raman spectra of the addition compounds $\text{TeCl}_4 \cdot \text{AlCl}_3$ and $\text{SeCl}_4 \cdot \text{AlCl}_3$ in the liquid as well as in the solid state show, besides other lines, three more or less characteristic strong lines, for which in the case of liquid $\text{TeCl}_4 \cdot \text{AlCl}_3$ some information has been obtained with regard to their polarization state. The frequencies of these lines are compared with those of the component parts and of the AlCl_4^- ion. The findings point to an ionic structure for both compounds ($\text{TeCl}_3^+ \cdot \text{AlCl}_4^-$ and $\text{SeCl}_3^+ \cdot \text{AlCl}_4^-$). The assigned frequency values for TeCl_3^+ and SeCl_3^+ in these compounds are somewhat higher than the corresponding lines in TeCl_4 and SeCl_4 . This makes it probable that the interaction between TeCl_3^+ (and SeCl_3^+) and its surrounding anions (Cl^- and AlCl_4^-

respectively) is stronger in the compound TeCl_4 (and SeCl_4) than in the corresponding addition compound. Force constants have been calculated for TeCl_3^+ in the compound $\text{TeCl}_4 \cdot \text{AlCl}_3$. A.

535.375.5

3635. On the Raman spectrum of solid and liquid H_2O_2 . A. SIMON AND H. KRIEGSMANN. *Note in Naturwissenschaften*, **42**, No. 1, 12 (1955).

Both forms show a line at 228 cm^{-1} attributed to torsional vibration. G. F. LOTHIAN

535.375.5

3636. Rayleigh scattering and rotational Raman effect in liquids. J. BRANDMÜLLER. *Z. Phys.*, **140**, No. 1, 75–91 (1955) In German.

Profiles of the Hg lines 4047 , 4358 , $5461 \text{ \AA}$ are measured photoelectrically before and after scatter from various liquids: C_6H_6 , CS_2 , CCl_4 , C_6H_{12} , $\text{C}_6\text{H}_5\text{CH}_3$ and H_2O . The difference of the 2 profiles shows peaks displaced $2\text{--}4 \text{ cm}^{-1}$ on each side of the exciting line. These are regarded as rotational Raman lines; the displacements are about $5 \times$ smaller than the values for the corresponding gases and the decrease is attributed to hindered rotation in the liquids. Peak intensities of the rotational lines are approximately $\propto$ the optical anisotropies. The total intensity of scatter shows some approximate correspondence with values calculated from density fluctuation data. G. F. LOTHIAN

535.375.5

3637. Some remarks on the Raman spectrum of solid phosphorus pentachloride. H. GERDING AND H. HOUTGRAAF. *Recueil Trav. chim. Pays-Bas*, **74**, No. 1, 5–14 (Jan., 1955).

Powell deduced from an X-ray study that solid PCl_5 has to be considered as $[\text{PCl}_4^+][\text{PCl}_6^-]$. From the distances between P and Cl in PCl_4^+ and in PCl_6^- given by the authors, force constants $f_{\text{PCl}_4^+}$ and $f_{\text{PCl}_6^-}$ have been calculated using Badger's rule. From these f values and by a comparison with the results of a similar calculation for SiCl_4 it follows that the strongest lines of the Raman spectrum of PCl_5 , namely $358(15)$ and $451(7)$, belong to $\nu_1(\text{PCl}_6^-)$ and $\nu_1(\text{PCl}_4^+)$ respectively. With these frequencies known it is possible to make an estimate of the frequencies to be expected for the other Raman-active vibrations of both ions. A probable assignment of Raman shifts to vibrations of PCl_4^+ and PCl_6^- is given. Force constants have been calculated for both ions, using formulae based on Nath's force field and on the orbital valence force field introduced by Heath and Linnett. Probable frequency values: PCl_4^+ 173, 244, 451, 627; PCl_6^- 244, 285, 358. A.

535.375.5

3638. The Raman spectrum of liquid and solid $\text{AlCl}_3 \cdot \text{NH}_3$. H. GERDING AND H. HOUTGRAAF. *Recueil Trav. chim. Pays-Bas*, **74**, No. 1, 15–23 (Jan., 1955).

An assignment of frequency shifts to vibrations of $\text{AlCl}_3 \cdot \text{NH}_3$ (symmetry C_{30}) has been given. Force constants have been calculated from these frequencies with Wagner's formulae. To the symmetrical stretching vibration of N–H in $\text{Cl}_3\text{Al} \cdot \text{NH}_3$ a frequency has

been assigned (liquid 3247 cm^{-1} ; solid 3259 cm^{-1}), which is higher than that assumed by Goubeau and Siebert (2900 cm^{-1}). The present value shows a rather small difference from the corresponding one in free NH_3 . A.

535.375.54

3639. Raman spectrum of fluorene. T. A. HARIHARAN. *J. Indian Inst. Sci. A*, **36**, No. 4, 215–17 (Oct., 1954).

By using the technique of complementary filters, the Raman spectrum of fluorene was recorded at room temperature and the frequency shifts are compared with those of an earlier investigation. The Raman spectrum of fluorene dissolved in benzene was also obtained in the usual manner for liquids. Extra lines have been identified at 31, 67, 93, 356, 628, 875, 1266 and 1494 cm^{-1} and are assigned. A.

535.375.54

3640. The Raman spectrum of diamond. D. KRISHNAMURTI. *Proc. Indian Acad. Sci. A*, **40**, No. 5, 211–16 (Nov., 1954).

The Raman spectra of fourteen different diamonds exhibiting diverse characters in their optical behaviour (viz. transparency in the infrared and ultraviolet regions of the spectrum, birefringence and the intensity and colour of the luminescence) were recorded. The principal Raman line is found to have a frequency shift of $1331.7 \pm 0.2\text{ cm}^{-1}$ which agrees closely with the value of 1331.8 cm^{-1} reported earlier. There were no observable variations in the frequency shift, width or intensity of the line in the several cases studied. A.

535.375.54 : 535.372

3641. Raman and fluorescence spectra of ortho- and para bromotoluene in the solid state at low temperatures. D. C. BISWAS. *Indian J. Phys.*, **28**, No. 9, 423–30 (Sept., 1954).

The Raman spectra of ortho- and para-bromotoluene in the solid state at different low temperatures are recorded. With solidification one line due to $\text{C}=\text{C}$ vibration of both the compounds diminishes in intensity. It is suggested that this fact indicates the association of some of the molecules in the solid state at the expense of the $\text{C}=\text{C}$ bond as in the case of polymerization of styrene. Only one new line at 94 cm^{-1} appears in the low-frequency region when ortho-bromotoluene is solidified and cooled down to -60°C . With lowering of temperature of the solid to -180°C , another line is observed at 36 cm^{-1} . In the case of the para compound in the solid state at -20°C , two lines are observed in the low-frequency region. With lowering of temperature of the solid to -180°C the intense line at 33 cm^{-1} disappears but three more extra lines appear in the low-frequency region. All these irregular changes are critically discussed. In the solid state at -180°C either of the substances exhibits two fluorescence bands in the visible region, the frequency difference between the bands being about 1600 cm^{-1} . It is suggested from the evidences available that the fluorescence of bromotoluenes in the solid state at -180°C is a property of the groups of molecules of the substances. A.

469

535.375.56

3642. The ν_2 Raman band of methane. T. FELDMAN, J. ROMANKO AND H. L. WELSH. *Canad. J. Phys.*, **33**, No. 3–4, 138–45 (March–April, 1955).

The doubly degenerate ν_2 band was photographed at a gas pressure of 2 atm. with a reciprocal linear dispersion of 10.5 cm^{-1} per mm. An analysis of the O and S branches gave $\nu_0 = 1533.6$, $B_0 = 5.270$, and $B_1 = 5.392\text{ cm}^{-1}$. When the Raman data are combined with the infrared data of Burgess, Bell and Nielsen, the effect of the Coriolis interaction of ν_2 with ν_4 is seen to be a splitting of the rotational levels of the upper vibrational state of ν_2 into two sets, each of which can be represented by an effective value of B_1 . The Raman O , S and the infrared P (strong), Q , R (weak) transitions terminate in states with $B_1 = 5.392\text{ cm}^{-1}$; the Raman P , Q , R and the infrared P (weak), R (strong) transitions terminate in states with $B_1 = 5.322\text{ cm}^{-1}$. A.

535.376

3643. Importance of solvent in liquid scintillators. F. N. HAYES, B. S. ROGERS AND P. C. SANDERS. *Nucleonics*, **13**, No. 1, 46–8 (Jan., 1955).

Results of experiments on characteristics of solvents in liquid scintillators are tabulated and graphed. The properties investigated include the wavelengths at which photons have mean free paths of 50, 100 and 200 cm, pulse heights (using Cs-137 internal-conversion electrons) from 3 g/litre solutions of 2,5-diphenyloxazole (PPO) in various alkylbenzenes; from 3 gm/litre solutions of PPO in toluene mixed with various quantities of other solvents and from different concentrations of PPO in 6 pure solvents. L. R. SHEPHERD

535.39

3644. Experimental determination of the reflection, transmission and absorption of thin films of haemin. R. RINALDI. *C.R. Acad. Sci. [Paris]* **240**, No. 1, 61–4 (Jan. 3, 1955) In French.

The films, formed on water, were deposited on to a glass slide, and the reflectivity of the film-air, and film-glass interfaces was measured, together with the transmission. The absorption in a film could then be calculated. The results confirmed a theoretical relation between the absorptions measured when the light is incident on the film from opposite sides, and also suggested that the films had a structure similar to very thin evaporated layers. D. G. AVERY

535.394

3645. New investigations on total reflection. J. PICHT. *Optik*, **12**, No. 1, 41–55 (1955) In German.

A theoretical investigation of total reflection of electromagnetic waves from a dipole, starting from a relation given previously by the author [*Ann. Phys. [Leipzig]* **77**, 685 (1925)]. From expressions developed curves are given showing, plotted against angle of incidence, the displacement of the totally reflected wave and the penetration into the second medium, both expressed in wavelengths. G. F. LOTHIAN

535.41 : 530.162

3646. The optical uncertainty principle of Ingelstam and phase objects. P. M. DUFFIEUX. *Rev. Opt.*, **33**, No. 10, 521–8 (Oct., 1954) In French.

Abstr. 2333 (1954) deduced an uncertainty principle connecting the amount of information obtained

in extension with the sensitivity of depth in multiple-beam interferometry. In the case of a plane phase object, consideration of the transmission functions shows this principle relates the quantity of information in extension to the loss of information on the phase. A method of reducing this loss is deduced, which improves the sensitivity of relief corresponding to a given quantity of information.

R. W. FISH

535.417

3647. The visibility of the fringes with a Twyman interferometer. G. HANSEN. *Optik*, **12**, No. 1, 5–16 (1955) In German.

A study is made of the relation between the size of the aperture and the geometry of the light paths. Only a compensated type interferometer is discussed. Cases treated include (1) when the beam splitter is at the focus of the collecting lens, (2) afocal systems, (3) arrangement for thick lenses, (4) arrangement for a plane-parallel plate, (5) set-up for a Kepler telescope with field lens in the image plane. The contrast in relation to the aperture is calculated and shown graphically.

S. TOLANSKY

535.417

3648. The set-up of the Mach-Zehnder interferometer. H. HANNES. *Optik*, **12**, No. 1, 17–22 (1955) In German.

A discussion of the generalized form of Mach-Zehnder interferometer, including localization. Conditions for practical adjustment of the 4 mirrors are analysed. Only two rotating and two displaceable mirrors are required. White light requires rotation of three mirrors.

S. TOLANSKY

535.417

3649. The dupligran method for evaluating interferograms. E. LAU. *Optik*, **12**, No. 1, 23–8 (1955) In German.

The dupligran method (moiré fringes) is an easily operated procedure for evaluating the interferogram of a lens system in a Twyman-type interferometer. The theory is developed. The moiré pattern is obtained by displacing the ring system relative to itself and superposing. The moiré pattern for a lens with spherical aberration is illustrated and its evaluation described. The method described permits rapid evaluation of interferograms of spherical and aspherical surfaces.

S. TOLANSKY

535.417

3650. Inverting interferometer. J. B. SAUNDERS. Letter in *J. Opt. Soc. Amer.*, **45**, No. 2, 133 (Feb., 1955).

An interferometer element is described which is a modification of the Köster's double prism. This produces interference by folding one part of the wavefront on to the other. The system has advantages. Typical applications are described. These include: (a) Method of testing a telescope objective; the symmetry is such that one set of fringes can be photographed whilst on the opposite side of the beam-splitter is an identical system which can be visually observed. (b) A modification which is rugged and permits measurement of stellar diameters on the system of the Michelson stellar interferometer; this again has two independent fringe images and is easily operated.

S. TOLANSKY

535.417 : 531.717.1

3651. Tolansky gauge for rapid measurement of film thickness. T. M. GREEN AND L. N. HADLEY. Letter in *J. Opt. Soc. Amer.*, **45**, No. 3, 228–9 (March, 1955).

A device is described which speeds up the measurement of thin film thickness when using the method of multiple-beam interference fringes. It is based on the displacement produced by an inclined glass plate. An image of the fringes is projected on to a glass plate which is itself viewed by a lens system. The angle to produce one fringe shift is determined. The angle to eliminate the fringe shift due to the stepped film is then measured. From these the mean fringe displacement from several fringes is rapidly evaluated. An accuracy of 50 Å in film thickness obtains.

S. TOLANSKY

535.417 : 532.72

3652. Measurements of optical path gradients by means of birefringence interferences. I. General and approximately linear gradients. II. Liquid gradients, in particular determination of diffusion constants. E. INGELSTAM. *Ark. Fys.*, **9**, Paper 12, 197–213, 213–226 (1955).

I. The factors entering into practical measurements of one-dimensional path gradients by means of birefringence interferences (using calcite or quartz) are examined. The arrangement used is in effect a phase-differentiating device, and special attention is paid to the influence of the amount of displacement of the two interfering beams due to the presence of higher derivatives in the phase gradient. This factor can be favourably modified mainly by variation of the azimuth angle of the specimen under test in relation to the analysing optical device. A special direct phase meter using a rotatable $\lambda/2$ ring has been constructed. The procedures are applied for (a) gradients in transparent specimens, and (b) angles between metallographical surfaces, which in this case can be obtained directly from a single azimuth measurement.

II. The case of a distribution of phases according to a Gaussian "error integral," the gradient following the "error curve," is investigated in detail, the corrections necessary in some cases being computed. Liquid gradients were produced experimentally, and it is proved that diffusion constants can be measured with an accuracy of a few percent with very simple means. Improvements in the photometric procedure give the higher accuracies that may be required. The main merit of the method is that the concentrations of solution may be so low as to correspond to an optical path increment over the solvent of less than one wavelength, i.e. in general concentration of the order of 0.01% for a cell of 10 mm thickness.

A.

535.42

3653. Theoretical and experimental study of the diffraction figure of a heliometer. N. SÉGARD AND A. VANDENBOSSCHE. *Ann. Soc. Sci. Bruxelles*, **1**, **68**, No. 3, 175–84 (1954) In French.

The method of Abstr. 9136 (1954) is applied to the case of a Bouguer heliometer which has a semicircular entrance pupil. The intensity distribution in the diffraction figure is calculated and compared with photographic records of the figure. Tables give the calculated values.

R. W. FISH

535.434
3654. Contribution to the theory of the optics of white sols. II. F. EVVA. *Z. phys. Chem. [Leipzig]* **203**, No. 1-2, 86-92 (May, 1954) In German.

For Pt I, see Abstr. 3343 (1954). Results of further calculations are plotted as curves of E/α , $v. \alpha$ (where E = scattering area coefficient and $\alpha = 2\pi n_0/\lambda$, r = particle radius and n_0 = refractive index for the dispersing medium) for lognormal distributions of spheres for refractive indices (n) 1.25, 1.33 and 1.55 and for various degrees of polydispersity (K). The ratio $E(\lambda = 496\text{m}\mu)/E(\lambda = 665\text{m}\mu)$ is also plotted against particle radius for various values of n and K ; these ratios are related to the dispersity quotients of Teorell. See *Kolloid Zeitschrift*, **54**, 150-6 (Feb., 1931).
 G. F. LOTHIAN

535.435
3655. On the anisotropic scattering of aqueous solutions of isotropic ions. A. ROUSSET AND R. LOCHET. *C.R. Acad. Sci. [Paris]* **240**, No. 1, 70-3 (Jan. 3, 1955) In French.

The increase of the anisotropic scattering of light by aqueous solutions of MgCl_2 with increasing concentration is explained by the increased anisotropy of water molecules bound to the isotropic Mg^{++} ions.
 G. F. LOTHIAN

535.514
3656. On a sodium nitrate polarization prism and a polarization plate of a scattering type. T. YAMAGUTI. *J. Phys. Soc. Japan*, **10**, No. 3, 219-21 (March, 1955).

Two types of polarizers are constructed, one being the "total reflection type" similar to the Feussner prism and the other the "scattering type," in which the principle of Christiansen filters is used. The former is made of a thin single crystal of sodium nitrate grown between two prisms of SK5 glass or two glass plates which are cemented to two prisms of the same kind of glass by Canada balsam. Elimination of organic binders to attach the crystal to the glass simplifies the manufacturing process as well as protecting the polarizers from deterioration due to deliquescence of the crystal. The polarizer of the "scattering type" is constructed by binding directly two roughly ground surfaces of SK5 glass plates with a thin single crystal of sodium nitrate. As SK5 glass has the same refractive index as that for the ordinary ray in sodium nitrate, and the orientation of the optical axis of the crystal is so chosen that it lies in the plane of the glass plate, the extraordinary ray is scattered at the boundaries between the crystal and glass, and only the ordinary ray proceeds in the direction of the incident light, when natural light is incident upon it.
 A.

535.55
3657. Elasto-optical constants of $\text{PO}_4\text{H}_2(\text{NH}_4)$ and SO_4Ni , $6\text{H}_2\text{O}$. B. DEVIOT. Letter in *J. Phys. Radium*, **16**, No. 2, 162 (Feb., 1955) In French.

The values obtained by the author are given together with those of other investigators. No dispersion of the birefringence is observed.
 H. G. JERRARD

535.557 : 541.64 : 532.13
 A theory of the Maxwell effect for solutions of chain macromolecules. See Abstr. 3476

535.61-15
3658. Development of the uses of infrared radiation. P. FLEURY. *Rev. Opt.*, **33**, No. 10, 489-91 (Oct., 1954) In French.

Introducing a conference on the infrared held in March, 1954, by the Comité français d'Optique. The question of names for various infrared regions is discussed. See also Abstr. 3538, 3553-4, 3558, 3590, 3664, 3675, 4220.
 G. F. LOTHIAN

535.7
 Physiological optics. Vision. See under "Medical science. Human physiology." Decimal classification 612.84

535.81
3659. A criterion of apodization. P. M. DUFFIEUX. *Rev. Opt.*, **33**, No. 11, 590-1 (Nov., 1954) In French.

Abstr. 10110 (1954) criticized the rule proposed by the present author for determining the parameters of an apodizing filter in terms of the aperture and diffraction figure. It is suggested here that the criticism is based solely upon a difference of meaning attached to the term "zeros of the diffraction figure." R. W. FISH

535.81
3660. A criterion of apodization. B. DOSSIER. *Rev. Opt.*, **33**, No. 11, 591-6 (Nov., 1954) In French.

A response to preceding abstract. The author contests the statement that only a difference of language is involved and illustrates the fundamental differences with examples.
 R. W. FISH

535.81
3661. New recording optical measuring instruments. H. PLESSE. *Optik*, **12**, No. 1, 29-40 (1955) In German.

After a brief account of methods used to record optical properties, the author describes three new commercial recording instruments. These are the Extinction recorder for use in electrophoresis, the Refractograph for the continuous recording of the refractive index of flowing liquids, and a recording spectrophotometer. The method of operation and performance of each is briefly described.
 R. W. FISH

535.822.17 : 535.511
3662. Phase and amplitude measurements through elliptical analysis of a phase-contrast image. H. WOLTER. *Z. Phys.*, **140**, No. 1, 57-74 (1955) In German.

These measurements are made by superimposing two phase-contrast images which are polarized at right angles to each other. Analysis of the vibration ellipse at each position in the image allows the amplitude to be determined with a mean error of $\pm 0.4\%$ and the phase with a mean error of $\pm \lambda/500$. Some practical details of the apparatus and its theory are given.
 R. W. FISH

535.89 : 537.523.4
3663. Investigations on light sources for spectral analysis. An electronically controlled spark generator. Á. BARDÓCZ. *Acta. phys. [Hungar.]* **4**, No. 2, 91-121 (1954) In German.

A detailed paper dealing with a wide range of circuits for controlled spark, or spark-arc, sources for analytical work. Triggering methods are given at length. There are typical oscillograms and a reference list containing 80 items.
 J. D. CRAGGS

535.89
3664. Infrared lamps of improved performance. F. GANS. *Rev. Opt.*, 33, No. 10, 491-4 (Oct., 1954) In French.

Filaments coated with tantalum carbide show about 25-30% better emission in the near infrared than tungsten filaments. G. F. LOTHIAN

HEAT 536

536.2
3665. Conduction of fluctuating heat flow in a wall consisting of many layers. V. VODIČKA. *Appl. sci. Res. A*, 5, No. 2-3, 108-14 (1955).

Van Gorcum [Abstr. 1791 (1951)] has pointed to interesting and important analogies between the theory of a passive four-pole and the conduction of heat waves through stratiform bodies. This paper generalizes in certain regards van Gorcum's ideas and draws their consequences for the case of a solid, bounded by two infinite parallel planes and consisting of any number of layers made from different materials. A.

536.2
3666. Heat waves in multilayer cylindrical bodies. V. VODIČKA. *Appl. sci. Res. A*, 5, No. 2-3, 115-20 (1955).

Generalizes the results of an analogy between the propagation of heat waves in stratiform bodies and the transmission of electrical waves through a passive four-pole, as given by van Gorcum (see preceding abstract). It extends the author's considerations on heat waves in an infinite multilayer flat wall to the case of cylindrical bodies. A.

536.2.01
3667. Thermal conductivity of indium-thallium alloys at low temperatures. R. J. SLADEK. *Phys. Rev.*, 97, No. 4, 902-15 (Feb. 15, 1954).

The thermal conductivity of a series of homogeneous, solid solution indium-thallium alloys containing up to 50 atomic per cent of thallium has been measured as a function of temperature at liquid helium temperatures and as a function of both longitudinal and transverse magnetic fields below T_c , the superconducting transition temperature in zero field. The normal state results agree quite well with the quasi-free electron theory of metals. The superconducting state results agree with the hypotheses that electrons in the "superconducting phase" neither transport heat nor scatter phonons. For pure indium, it was found that $K_{es}/K_{en} = 2t^2/(3 + t^4)$, where K_{es} and K_{en} are the electronic thermal conductivities at a given temperature when the specimen is superconducting and when it is non-superconducting, respectively, and $t = T/T_c$. For all the alloy specimens the ratio of the lattice thermal conductivities comprised a family of curves such that $t^{-3} < K_{gs}/K_{gn} < t^{-6}$. A thermal resistivity maximum was found to accompany the isothermal destruction of superconductivity by either a longitudinal or a transverse magnetic field in specimens containing 15% Tl or more. When the applied field was reduced to zero, the final thermal resistivity of most of these specimens was greater than would be expected for a simple mixture of superconducting and "frozen-in" normal regions, the con-

centration of the latter being estimated from magnetic induction measurements. Both this effect and the maxima themselves are thought to be manifestations of an increased lattice thermal resistivity due to alteration of the mean free path of phonons when they approach the boundary between a superconducting and a normal region. A.

536.2.01 : 536.48
3668. The thermal conductivity of metals at low temperatures. H. M. ROSENBERG. *Phil. Trans A*, 247, No. 933, 441-97 (1955).

The thermal conductivity of high-purity samples of thirty-two metals has been measured. These were Ag, Al, Au, Be, Cb, Cd, Ce, Co, Cu, Fe, Ga, In, Ir, La, Mg, Mn, Mo, Ni, Pb, Pd, Pt, Rh, Sb, Sn, Ta, Ti, Tl, U, V, W, Zn and Zr. For most metals measurements were taken from 2 to 40°K, but where necessary they were extended to 90°K. For superconductors they were taken in both the superconducting and normal states. The conductivity was found to be entirely electronic except for Sb and U. Most of the specimens were polycrystalline, but single crystals of Zn, Cd, Sn, Pb, Ga and Ti were measured. For Zn and Ga, specimens of different orientations with respect to the rod axis were obtained, and in both these metals the thermal conductivity was found to be anisotropic. The thermal resistance, W , at low temperatures of nearly all the metals is of the form $W = \alpha T^2 + \beta/T$, and the constants α and β have been calculated. If K_∞ is the limiting thermal conductivity at high temperatures and θ is the Debye temperature, then the value of $\alpha K_\infty \theta^2$ is the same for the metals in any one chemical group. For some metals the electrical resistance was measured at the same time as the thermal conductivity over the full temperature range and hence the Lorenz number, L , was calculated. The limiting value of L at low temperatures for several metals was found to be considerably higher than the theoretical value, in particular for Ti and Zr. A corresponding effect to the minimum in the electrical resistance of Mg has been found in the thermal resistance. A large increase in the thermal conductivity of Fe after a period of time has been ascribed to the precipitation of impurities in the metal. A method is given for estimating the thermal conductivity of a metal at low temperatures. A.

536.222
3669. Thermal conductivities of condensed gases. I. The thermal conductivity of liquid nitrogen between 65 and 90°K. R. W. POWERS, R. W. MATTOX AND H. L. JOHNSTON. *J. Amer. Chem. Soc.*, 76, No. 23, 5968-71 (Dec. 5, 1954).

A cell for measuring the thermal conductivity of liquids at low temperatures is described. Data on the conductivity of liquid nitrogen from 65 to 90°K are presented. These data are considerably lower than those of Hammann (1938) and compare closely with those given by Borovik, Matveev and Panin (1940). A.

536.222
3670. Thermal conductivity of condensed gases. II. The thermal conductivities of liquid normal and of liquid parahydrogen from 15 to 27°K. R. W. POWERS, R. W. MATTOX AND H. L. JOHNSTON. *J. Amer. Chem. Soc.*, 76, No. 23, 5972-3 (Dec. 5, 1954).

The thermal conductivities were found to be inde-

pendent of the ortho-para composition and can be expressed by the equation $K = (1.702 + 0.05573T) \times 10^{-4}$, cal. cm⁻¹ sec⁻¹ deg⁻¹. It is believed that the probable error is within 2%. A.

536.222

3671. Thermal conductivity of condensed gases. III. The thermal conductivity of liquid deuterium from 19 to 26°K. R. W. POWERS, R. W. MATTOX AND H. L. JOHNSTON. *J. Amer. Chem. Soc.*, **76**, No. 23, 5974 (Dec. 5, 1954).

The thermal conductivities of normal and ortho-deuterium were found to be the same within the limits of experimental error and can be expressed by the equation $K = (2.020 + 0.04965T) \times 10^{-4}$, cal. cm⁻¹ sec⁻¹ deg⁻¹. The conductivity of liquid deuterium was found to be about 6% greater than that of liquid hydrogen. A.

536.24 : 621.36

3672. Physical principles of electric space heating. H. MÜLLER. *Elektrowärme-Techn.*, **5**, No. 9-10, 187-93 (Sept.-Oct., 1954) In German.

The various physical factors governing space heating, including heat transfer, humidity, air flow and the effect of persons present in the space to be heated, are discussed and their influence illustrated graphically. Particular points to be considered when choosing a form of heating for a building are outlined briefly.

S. WEINTROUB

536.24.01 : 532.517

3673. Some remarks on heat and mass transfer across the boundary layer. G. RIBAUD. *C.R. Acad. Sci. [Paris]* **240**, No. 1, 25-8 (Jan. 3, 1955) In French.

On the basis of Blasius's formulae for the laminar boundary layer and the seventh-root law for the turbulent case it is shown that $\frac{1}{3}$ of the molecules in the free stream does not penetrate the laminar, and $\frac{1}{3}$ the turbulent, boundary layer. Simple considerations also show that, with Prandtl number equal to unity, about 10% of the heat flux reaches the flat plate boundary in either case.

A. GELBTUCH

536.25 : 537.212

3674. On electro-thermal convection in air. A. G. OSTROUMOV. *Zh. tekhn. Fiz.*, **24**, No. 6, 1055-61 (1954) In Russian.

Describes the design of an optical method of studying convection under the joint influence of gravitational and electric fields. The results obtained show that a non-uniform electric field will also cause convection and, if the field is large enough, will be the controlling factor. It was found that the effect was greater for a less powerful source of heat.

J. M. HOUGH

536.33.08

3675. Amplifier for thermopiles. L. RECARTE. *Rev. Opt.*, **33**, No. 10, 504-7 (Oct., 1954) In French.

An amplifier has been built consisting of input transformer (I), preamplifier, tuned twin-T circuits and measuring circuits. It is described in general terms, with more particular discussion of the design of I to limit the noise level to that of the thermopile. At a frequency of 3c/s and a bandwidth of 0.1 c/s, the noise level is 10^{-9} V input. G. F. LOTHIAN

536.421.1

3676. Contraction of germanium on melting. R. C. SANGSTER AND J. N. CARMAN, JR. Letter in *J. chem. Phys.*, **23**, No. 1, 206-7 (Jan., 1955).

Description of experimental results in general agreement with those of Klemm, Spitzer, Lingenberg and Junker (*Monatshefte für Chemie*, **83**, 629 (1952).

C. A. HOGARTH

536.421.1

3677. Atomistic interpretation of the melting of simple compounds. W. A. WEYL. *J. phys. Chem.*, **59**, No. 2, 147-51 (Feb., 1955).

Earlier attempts to correlate the melting temperature of simple compounds with a single parameter such as character of the bond or bond strength have failed. The author has developed a physical concept which accounts for the fact that most elements are solids and that only a very few (noble gases) can form single atoms under normal conditions. This concept, the need of positive cores to be screened by electrons or anions, is used to explain the wide spread of melting temperatures of simple compounds, oxides or fluorides. The anion to cation ratio is the most important single factor. The melting points increase from fluorides to oxides, nitrides and carbides. For highly charged cations the melting point increases with increasing size of the cation (C⁴⁺, Si⁴⁺, Zr⁴⁺, Th⁴⁺) because more anions are required for screening the larger cores. Increasing the charge of the cation (Na⁺, Mg²⁺, Al³⁺, Si⁴⁺) produces two antagonistic effects: it increases the need for screening the core but it also increases the number of anions required for electroneutrality. The screening requirements depend on the sizes, charges and polarization properties of the anions and cations. There is no single parameter which controls the melting temperature, but within series of compounds a plausible explanation for the melting temperatures can be derived. A.

536.421.1 : 548.5

3678. Melting and crystal structure: the melting parameters of some polyphenyls. J. N. ANDREWS AND A. R. UBBELOHDE. *Proc. Roy. Soc. A*, **228**, 435-47 (1955).

Melting mechanisms have been studied for diphenyl, and *o*-, *m*- and *p*-terphenyl. The volume increase on melting is largest for the linear polyphenyls and smallest for branched molecules which can interlock in the melt. In no case will the volume increase permit the "onset of rotation" on melting. Viscosity measurements give marked indications of the growth of cybotactic groups in the melts on approaching the freezing-points, especially in the case of *o*-terphenyl, where the ratio H_{vap}/E_{η} reaches exceptionally low values near the freezing-point. Plots of fluidity against specific volume and the marked tendency of the melt of *o*-terphenyl to supercool give further indications of the presence of interlocked groups of molecules in the melt. A.

536.422.1 : 541.123.2

3679. Mass spectrometric study of gaseous species in the Si-SiO₂ system. R. F. PORTER, W. A. CHUPKA AND M. G. INGRAM. Letter in *J. chem. Phys.*, **23**, No. 1, 216-17 (Jan., 1955).

Gaseous mixtures produced by vaporizing Si-SiO₂

mixtures and SiO_2 under neutral oxidizing conditions were investigated spectrometrically between temperatures of 1200°K and 1950°K. Apart from SiO gas, ion currents of SiO^+ and Si_2O_2^+ were observed at low temperature; at higher temperature SiO_2^+ , O_2^+ and O^+ were also found. Appearance potentials were 10.8 eV (SiO^+), 11.7 eV (SiO_2^+) and 10 eV (Si_2O_2^+). The equilibrium partial pressures were also obtained. The heat of sublimation of SiO_2 was calculated. A. J. TAYLOR

536.422.5

3680. A note on the preparation of solid ozone and atomic oxygen. H. P. BROIDA AND J. R. PELLAM. Letter in *J. chem. Phys.*, **23**, No. 2, 409 (Feb., 1955).

See Abstr. 8226 (1954). Gaseous products of a high-frequency electrodeless discharge through oxygen are condensed on a Pyrex surface at 4.2°K. If the vessel is clean and dry, ozone is deposited directly on the surface. If water vapour is first admitted to the vessel, an active material is deposited, which on heating forms solid ozone. It is suggested that the active material contains free oxygen atoms. T. P. BRODY

536.423

3681. Effect of thermal resistance of a liquid in some cases of evaporation of a liquid and condensation of a vapour from vapour-gas mixtures in film apparatus. L. D. BERMAN. *Zh. tekhn. Fiz.*, **24**, No. 6, 1022-34 (1954) In Russian.

It has been claimed by McAdams [*Chemical Engineering Progress*, **45**, No. 4, 241 (1949)] that it is not justified to assume that, when heat and mass transfer occurs between liquids and saturated vapours at low rates of heat flux, the effect exerted by the thermal resistance of the liquid on the rate of evaporation or of condensation can be neglected. This paper contains a critique of the bases on which McAdams drew this conclusion, which is shown to be unfounded, from an analysis of the author's own, and other published work on the subject. The exact nature of the effect cannot be deduced from McAdams's own experiments, and requires further study. R. C. MURRAY

536.423 : 537.57

3682. Influence of ions on the nucleation processes in liquids. II. Liquids under positive pressure in metastable thermodynamical equilibrium (overheated liquids). L. BERTANZA AND G. MARTELLI. *Nuovo Cimento (Ser. 10)*, **1**, No. 2, 324-36 (Feb., 1955).

For Pt I, see Abstr. 10132 (1954). The behaviour of liquids in metastable equilibrium under positive pressure has been investigated, and an expression for the total flux of "critical" bubbles carrying different numbers of ions has been found. A comparison between results and some experimental data shows that in some cases the contribution of the ions at the nucleation processes in overheated liquids cannot be neglected. The total flux of bubbles is larger than that obtained when the effect of the ions is neglected: the waiting times are therefore shorter and, in some cases, become zero effectively. A.

536.423.1 : 532.63

3683. Influence of capillarity on the boiling point of water. M. L. LAKHANPAL, R. K. SUD AND B. R. PURI. *J. phys. Chem.*, **59**, No. 2, 160-1 (Feb., 1955).

An apparatus for determining boiling points of

capillary condensed moisture is described. Boiling points of water held up in four different porous bodies, at different relative vapour pressures, were determined and the results obtained are compared with the theoretical values derived from thermodynamic considerations. The results offer support to the theory of capillary condensation. A.

536.423.15

3684. Vapor pressure of nitrogen. G. T. ARMSTRONG. *J. Res. Nat. Bur. Stand.*, **53**, No. 4, 263-6 (Oct., 1954).

This has been measured in the liquid range below the normal boiling point and can be represented by $\log P \text{ (mm)} = 6.49594 - 255.821/(T - 6.600)$. The normal boiling point calculated from this equation is 77.364°K. Nitrogen vapour densities along the saturation line are represented by $\log \rho T = 3.39858 - 282.953/(T - 3.83)$. The fugacity function $\ln f/p$ for the saturated vapour is tabulated. A.

536.423.15 : 541.24

3685. Measurement of the molecular weights of vapors at high temperature. II. The vapor pressure of germanium and the molecular weight of germanium vapor. A. W. SEARCY AND R. D. FREEMAN. *J. chem. Phys.*, **23**, No. 1, 88-90 (Jan., 1955).

These have been determined by use of an apparatus for the simultaneous measurement of the weight of vapour effusing through two small orifices and of the force exerted by the effusing vapour. The molecular weight of germanium vapour at 1750°K was found to be 58 ± 16 compared to the atomic weight of 72.60. The heat of sublimation of germanium at 298°K is 91.5 ± 3.0 kcal. A.

536.44

3686. The properties of substances at the critical point. J. VAN DRANEN. Letter in *J. chem. Phys.*, **23**, No. 1, 218 (Jan., 1955).

Calculation of a value for the kinetic energy of disturbed rotation at the critical point [Abstr. 2388 (1954)] shows that the energy associated with the freely rotating molecules is, for ethene, 73% of the normal value, for propene 69%. W. GOOD

536.461

3687. Effect of solid surfaces on the propagation of flame through ethylene-air mixtures. M. F. HOARE AND J. W. LINNETT. *J. Chem. Soc.*, **1955**, 195-202 (Jan.).

Three types of experiment have been carried out to investigate the effect of solid surfaces on the propagation of flame through various ethylene-air mixtures. These are: (A) Measurements of minimum tube diameters for flame propagation. (B) Measurements of critical flow rates for flash-back down cylindrical burner tubes; from these critical velocity gradients at the wall and penetration distances have been calculated. (C) Observations of the products of combustion after explosion in a small combustion chamber; from the results it was concluded that a portion near the wall was not consumed by the flame. The results are discussed separately and in relation both to one another and to some measurements by Holm and by Lewis and von Elbe. A.

536.462

3688. Burning rate studies. I. Measurement of the temperature distribution in burning liquid strands. D. L. HILDENBRAND, A. G. WHITTAKER AND C. B. EUSTON. *J. phys. Chem.*, **58**, No. 12, 1130-3 (Dec., 1955).

Fine wire thermocouples (0.0003 in. diameter) carefully prepared by micromanipulative techniques have been used to explore the temperature distribution in several burning liquid systems as an aid in the theoretical approach to liquid combustion. The experimental temperature-time records were combined with simultaneously determined liquid consumption rates to give the steady-state temperature distance curves. Work has been chiefly concerned with the liquid phase profiles and of the effect of variables such as liquid viscosity on the shape of the profile. High-speed motion pictures of the burning process have been synchronized with the temperature-time records to determine the relative positions of the thermocouple and the liquid surface. The three liquid systems studied thus far have been the two component systems 2-nitropropane-nitric acid, metriol trinitrate cooled with triacetin and ethylnitrate. Emphasis has been on interpretation of the data and their application to determining surface temperature.

A.

536.48

3689. Vapour pressures of He³-He⁴ mixtures. S. M. BHAGAT AND P. K. KATTI. *Progr. theor. Phys.*, **12**, No. 3, 380-2 (Sept., 1954).

536.48 : 539.185.7

Transmission of slow neutrons by liquid helium. See Abstr. 4109

536.48 : 539.26

3690. X-ray diffraction patterns from liquid helium. W. L. GORDON, C. H. SHAW AND J. G. DAUNT. Letter in *Phys. Rev.*, **96**, No. 5, 1444-5 (Dec. 1, 1954).

Measurements are made with copper K α radiation at temperatures of 4.2 and 1.4° and scattering angles between 1.5 and 90°. In calculating the liquid structure factor scattering of a gas is used for estimating the intensity due to independently scattering atoms. Results are presented in form of a graph in which the liquid structure factor is plotted against the scattering angle. The curves for helium I and helium II are of a similar type; their main difference is the small-angle intensity which is very much lower at the lower temperature.

R. EISENSCHITZ

536.48 : 536.655

3691. The heat of evaporation of helium. J. VAN DRANEN. Letter in *J. chem. Phys.*, **23**, No. 1, 213 (Jan., 1955).

The hypothesis that at the critical point $K_c + U_c = 0$ [Abstr. 8364 (1953)] has been used to calculate the heats of evaporation of He(4) at several temperatures. The results agree reasonably.

C. TURNER

536.48 : 539.153.4

3692. Generalization of Feynman's theory of energy levels of liquid helium. H. MATSUDA. *Progr. theor. Phys.*, **12**, No. 4, 537-44 (Oct., 1954).

Feynman's method of finding the lower energy levels of liquid helium is generalized to include

energy levels corresponding to a number of excitons. The expectation values of momentum in these levels are calculated. This extension is valid so long as the number of excitons is small compared with that of atoms, and no pair of excitons with wave numbers equal in magnitude but opposite in sign co-exists. The excitons derived according to this scheme are found to behave as bosons. The interaction potential between helium and the surrounding wall can be regarded as a creation and an annihilation operator of the excitons. The usual hypothesis for the critical velocity is discussed in this connection.

A.

536.48

3693. Supercritical damping of oscillating disks in liquid helium II. J. G. DASH. *Phys. Rev.*, **97**, No. 4, 1038-42 (Feb. 15, 1955).

The damping of a torsion pendulum in liquid He II, for relative velocities exceeding the critical velocity, is calculated from the phenomenological theory of superfluid dynamics. The logarithmic decrement of a single disk and of an array of thin disks are treated with some simplifying assumptions and compared with the observations of Hollis-Hallett. Quantitative comparison indicates that the strength of the supercritical ρ_s -wall interaction is given by $k = 8 \times 10^{-3} a^{-\frac{1}{2}} \text{ g cm}^{-4}$ over a considerable range of a .

A.

536.48

3694. Measurements of the thermomechanical effect in helium II near 1°K. V. P. PESHKOV. *Zh. éksp. teor. fiz.*, **27**, No. 3, 351-4 (1954) In Russian.

Measurements are made from 1.59 down to 0.817°K. ΔP v. ΔT graphs are shown to be linear and to coincide for measurements made during heating and cooling. The values observed were of the order of a few cm helium at ΔT of some 10^{-2} deg. The heat of transfer is calculated and used for deriving the entropy as a function of temperature; agreement with entropies as derived from the specific heat are satisfactory. The normal fraction is derived from the heat of transfer, the specific heat and the velocity of second sound at a number of temperatures. Agreement with Landau's theory is claimed within the limits of experimental accuracy, estimated to be 10%.

R. EISENSCHITZ

536.62

3695. A new high-temperature reaction calorimeter. The heats of mixing of liquid lead-tin alloys. O. J. KLEPPA. *J. phys. Chem.*, **59**, No. 2, 175-81 (Feb., 1955).

The calorimeter is particularly suited for the study of heats of mixing and heats of solution in alloy systems for temperatures up to 500°. The calorimeter is quasi-isothermal. The change in temperature of the calorimeter during a reaction is determined by comparison with that of a surrounding jacket which has a large heat capacity compared to the calorimeter proper. The jacket is maintained at constant temperature in the furnace by introducing a large thermal lag between the controlled heating system and the jacket. The calorimeter has been used for a redetermination of the heats of mixing of liquid lead-tin alloys. Results are presented for 350 and 450°.

A.

536.62
3696. An adiabatic calorimeter for measuring the specific heats of liquids in the range 0 to 100°C. L. W. PHIPPS. *J. sci. Instrum.*, **32**, No. 3, 109–13 (March, 1955).

A calorimeter is described, capable of measuring specific heats within small temperature intervals (2 or 3°C). An accuracy of $\pm 0.5\%$ can be maintained throughout the full working range, with a small increase in precision between 10 and 30°C. Features of the design include: an electrically heated annular metal jacket; stirring of the calorimetric fluid (125 cm³) by an oscillation of the calorimeter about its vertical axis (this has certain advantages over the conventional motor-driven shaft and paddle); a calorimeter heater design giving wide dispersal of heat without local overheating; ease of assembling and dismantling. Primarily designed for measurements on liquid dairy products, it can be used for other liquids. Typical results with the former are illustrated. A.

536.631 : 536.48

3697. A new vacuum calorimeter for low temperatures. K. G. RAMANATHAN AND T. M. SRINIVASAN. *Phil. Mag.*, **46**, 338–40 (March, 1955).

A cryostat with a hermetically sealed vacuum calorimeter has been developed for investigating the specific heats of solids at low temperatures. The use of an exchange gas and the operation of high-vacuum equipment necessary with calorimeters of conventional design are avoided by the introduction of a mechanical arrangement which can make or break a thermal contact of the specimen with the bath as necessary. With slight modifications in technique the cryostat, which is now being used for measurements in the liquid helium range, could also be used for calorimetry up to 50°K. Its performance has been tested by some preliminary measurements on the specific heat of tin in the range 1.5–4.2°K. A.

536.633 : 537.56

3698. Heat capacity of gases at high temperatures. B. L. TIMAN. Letter in *Zh. eksper. teor. Fiz.*, **27**, No. 2, 262–4 (1954) In Russian.

A theory is given for the temperature range in which the atoms are ionizing due to the magnitude of the thermal energy. The theory is evaluated for hydrogen and it is shown that above 5000°K ionization begins to be important and the thermal capacity increases up to about 20000°K when it has a value of about 20 times that for the non-ionized gas and then decreases to a value of twice that of the non-ionized gas.

J. M. HOUGH

536.654

3699. The heat of sublimation of carbon. M. HOCH, P. E. BLACKBURN, D. P. DINGLEY AND H. L. JOHNSTON. *J. phys. Chem.*, **59**, No. 2, 97–9 (Feb., 1955).

This has been studied by measuring the partial pressure of carbon gas above graphite, tantalum carbide and tungsten carbide. The vacuum evaporation method of Langmuir was used; the temperature range investigated extended from 2170 to 2770°K. The partial pressures measured are of the same order of magnitude in all three cases. Therefore, the evaporation mechanisms of carbon from graphite and the carbides are identical. This implies that: (1) the

accommodation coefficients of carbon gas on graphite and the carbides are closely the same and between 0.1 and unity; (2) the species in the gas are the same, the gas consisting to a considerable extent of C₁. Thus, the heat of sublimation of carbon is $\Delta H_0^\circ = 170$ kcal/mole at 0°K. A.

536.654

3700. Direct determination of the heat of sublimation of carbon with the mass spectrometer. W. A. CHUPKA AND M. G. INGRAM. *J. phys. Chem.*, **59**, No. 2, 100–4 (Feb., 1955).

The vapour pressures and the temperature dependence of the vapour pressures of C, C₂ and C₃ above graphite have been measured. The experiment involved the use of a mass spectrometer to study separately the C, C₂ and C₃ effusing from a Knudsen cell. The measurements yield values of 170, 190 and 200 kcal/mole, respectively, for the heat of vaporization of these species. Conflicting results of other workers are discussed. A.

536.658

3701. Heat of chemisorption of hydrogen in metals. D. P. STEVENSON. Letter in *J. chem. Phys.*, **23**, No. 1, 203 (Jan., 1955).

If the electronegativities of the metals are calculated from the formula $X_M = 0.355\phi_m$, ϕ_m being the work function in eV/atom, and Pauling's assignment of electronegativities for the adsorbate atoms are taken, better agreement than hitherto between calculated and observed heats of adsorption is obtained. W. GOOD

THERMODYNAMICS 536.7/.8

536.7

3702. Irreversible systems, entropy, and Riemann spaces. A. W. WUNDHEILER. *Proc. Nat. Acad. Sci. U.S.A.*, **40**, No. 9, 844–8 (Sept., 1954).

A detailed examination of the fundamentals of thermodynamic theory. General expressions are derived for entropy change and for the degradation. The latter is obtained in a quadratic form and it is claimed that the derivation removes the phenomenological status of Onsager's coefficients which are now expressed in terms of the basic concepts of conventional thermodynamics. The relationship to Bridgman's characteristic entropy increase is discussed.

F. E. HOARE

536.7

3703. Thermodynamical properties of air for temperatures between +75° and –170°C and pressures up to 1200 atmospheres. A. MICHELS, T. WASSenaar AND G. J. WOLKERS. *Appl. sci. Res. A*, **5**, No. 2–3, 121–36 (1955).

536.7

3704. Phenomenological equations and Onsager relations. The case of dependent fluxes or forces. G. J. HOOYMAN AND S. R. DE GROOT. *Physica*, **21**, No. 1, 73–6 (Jan., 1955).

The influence of linear dependencies between the fluxes or between the forces occurring in the expression for the entropy production on the phenomenological coefficients and the Onsager reciprocal relations

is investigated. If both sets of variables are dependent the phenomenological coefficients are not uniquely defined. It is shown that they can always be chosen such as to satisfy the Onsager relations. A.

ELECTRICITY 537

ELECTROSTATICS . DIELECTRICS 537.2

537.217 : 539.23 : 541.183

3705. The energy of interaction in an adsorbed film composed of dipoles. J. C. P. MIGNOLET. *Bull. Soc. Roy. Sci. Liège*, **23**, No. 12, 422-5 (Dec., 1954) In French.

A formula is derived for the electrostatic repulsion within a film composed of dipoles, in terms of the length of the dipoles, the charge, and the area occupied per dipole. S. J. GREGG

537.22 : 621.317.32 : 621.315.61

3706. Measurements of electrical polarization in thin dielectric materials. R. W. TYLER, J. H. WEBB AND W. C. YORK. *J. appl. Phys.*, **26**, No. 1, 61-8 (Jan., 1955).

Polarization induced by handling or other means is not readily observed because the external field from a dipole charge layer is very weak compared with the field from net charges that are usually present. A method is described for measuring polarization in the presence of net charges by placing the dielectric sheet in contact with a grounded metal backing plate and by placing a field meter at a short distance in front of the dielectric. The grounded metal backing plate has the effect of almost completely annulling the external field of any net charge by induction, and of doubling the external field of a dipole charge layer of polarization. A.

537.226.1

3707. The theory of the dielectric constant of ionic crystals. II. Effect of temperature. J. YAMASHITA. *Progr. theor. Phys.*, **12**, No. 4, 454-60 (Oct., 1954).

For Pt I, see Abstr. 432 (1954). The temperature effect has been calculated by determining the wavefunctions of ions required to minimize the free energy change of the system under electrostatic field. The numerical value of the coefficient of the temperature variation of LiF crystal becomes of 3.2×10^{-4} in comparison with the observed value of 3.75×10^{-4} . A.

537.226.1

3708. Influence of molecular shape on the dielectric constant of polar liquids. F. BUCKLEY AND A. A. MARYOTT. *J. Res. Nat. Bur. Stand.*, **53**, No. 4, 229-44 (Oct., 1954).

The Onsager theory of the static dielectric constant of polar liquids has been modified to allow for the influence of molecular shape. Equations have been derived for both prolate and oblate spheroids in which the permanent dipole is directed along the axis of symmetry. These equations have been applied to a number of pure polar liquids, exclusive of the hydrogen bonded liquids, where reliable data were available

over extended ranges of temperature. A satisfactory interpretation of the variation of dielectric constant with temperature is obtained provided the volume of the molecular cavity is maintained fixed and independent of temperature rather than allowed to expand in proportion to the molar volume as assumed by Onsager. The required molecular shapes are in general accord with the actual molecular geometries. The behaviour of dilute solutions and mixtures with a non-polar solvent are also satisfactorily correlated using the same shape parameters. It appears to be unnecessary to consider specific interactions between neighbouring molecules in order to account for the static dielectric behaviour of these systems. A.

537.226.2

3709. The dielectric constant of "free" and "bound" water at microwave frequencies. J. BARUCH AND W. Low. *Bull. Res. Coun. Israel*, **3**, No. 1-2, 31-6 (June-Sept., 1953; publ. Nov., 1953).

Mainly a discursive review of dielectric dispersion and absorption in liquid water, water of crystallization in $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, adsorbed water in CaCl_2 and NaCl , in silica gel and other gels, and in yeasts. Some new experimental results, obtained at one frequency only, are included. F. F. ROBERTS

537.226.2 : 535.343

3710. Microwave dispersion of monosubstituted benzenes; evidence for molecular resonance absorption. J. P. POLEY. Letter in *J. chem. Phys.*, **23**, No. 2, 405-6 (Feb., 1955).

Differences between n^2 from visible or infrared refractive indices and ϵ_∞ from the dielectric constant on the high-frequency side of the microwave dispersion indicate dielectric dispersion proportional to the square of the dipole moment to occur in the millimetre wavelength range. This is believed to be associated with oscillatory resonance of the whole molecule in liquids such as substituted benzenes. D. H. WHIFFEN

537.226.3

3711. Absorption of 3.18 cm microwaves in some aromatic and aliphatic compounds in the liquid state. D. K. GHOSH. *Indian J. Phys.*, **28**, No. 10, 485-9 (Oct., 1954).

The absorption of 3.18 cm microwaves in *o*-cresol, *m*-cresol and 3-chloropropene has been studied by the direct optical method avoiding formation of stationary waves. Maximum absorption was exhibited by *o*-cresol, *m*-cresol and 3-chloropropene at temperatures 50°, 80° and -80°C respectively. In the case of cresols these are assumed to be due to rotation of the OH group about the diameters of the molecule passing through the carbon atoms to which the OH group is attached. In the case of 3-chloropropene probably the rotor is rotating around the length of the molecule. It has been observed that toluene, *o*-bromotoluene and xylenes do not exhibit any absorption in the 3.18 cm microwave region, which corroborates views expressed in previous papers that the absorption in the microwave region is due to the rotational freedom of the group containing permanent electric moment about an axis of the molecule. Toluene and *o*-bromotoluene also do not exhibit any absorption in the u.h.f. region 250-900 Mc/s. This

may be due to the fact that the permanent electric moment in the case of toluene is very small and that the moment of inertia of *o*-bromotoluene is very high.

A.

ELECTRIC CONDUCTION . CURRENTS 537.3

537.3.08 : 621.317.351

3712. Oscillographic measurements of probability distributions. W. F. SCHREIBER. Letter in *Rev. sci. Instrum.*, **26**, No. 1, 88 (Jan., 1955).

See Abstr. 283 (1955). Refers to prior publications.

537.3.08 : 621.317.351

3713. Probability distribution measurements with the oscilloscope. L. W. ORR. Letter in *Rev. sci. Instrum.*, **26**, No. 1, 88 (Jan., 1955).

Reply to comments in preceding abstract.

537.311.1

3714. Investigation of the conduction mechanism of intermetallic compounds. H. BRUNS AND G. LAUTZ. *Abhandl. Braunschw. Wiss. Gesell.*, **6**, 47–61 (1954) In German.

Recent work indicates two distinct groups of inter-metallic compounds: those with a metallic behaviour and those with semiconducting properties. The measurement of the temperature-dependence of the electrical conductivity, of the thermoelectric power and the Wiedemann–Franz–Lorenz ratio in this paper should shed some light on the boundary between these two groups. The authors show that in the system ZnSb the intermetallic compound ZnSb is a semiconductor. Its properties are discussed in detail in connection with the isomorphous semiconducting compound CdSb. In this way one obtains some insight into the structure of the chemical bond and the stability of these compounds. Careful observations of the electrical conductivity of alloys with a small deviation in the stoichiometric concentration, of the compound ZnSb prove that Zn_3Sb_2 also is in some modifications a real semiconductor. Investigations on the electrical properties of alloys in the system InBi show that InBi is a metallic compound. This behaviour is in contradiction to the well-known InSb. The variation of the electrical properties when Bi-atoms are substituted for Sb-atoms in InSb is discussed in connection with the crystal structure. Similar experiments on Au_2Bi and $AuSb_2$ confirm the metallic character of both compounds. In contradiction to the statements on InSb–InBi there is no change in the electrical properties from a metallic to a semiconducting behaviour, although the relations between these compounds are very similar to those between the ZnS and wurtzite-type structure. Experiments and theoretical discussions confirm the fact that there is a large number of physical parameters, at lattice-type, electronic configuration, electronegativity, chemical bond, etc., which determine the nature of the electronic conduction. For a quantitative determination of the boundary between metallic and semiconducting compounds it is necessary to make further measurements in the present manner.

A.

537.311.1 : 539.213

3715. On the nature of the electrical conductivity of glass. R. L. MYULLER. Letter in *Zh. éksp. teor. Fiz.*, **27**, No. 2, 264 (1954) In Russian.

Various possible mechanisms are briefly reviewed with particular reference to whether the current is carried by ions or electrons.

J. M. HOUGH

537.311.22 : 621.3.011.22

3716. The resistance of an elliptic plate. E. E. JONES. *Brit. J. appl. Phys.*, **6**, No. 3, 88–90 (March, 1955).

The resistance of a thin conducting plate, with an elliptic contour, is determined (1) when the current enters the plate at an internal electrode and flows out at the circumference of the plate, and (2) when the current enters and leaves the plate at two internal electrodes. The formulae for the resistance are in the form of infinite series, capable of numerical evaluation to any degree of approximation. Examples are considered for both the current distributions.

A.

537.311.31 : 536.48

3717. The electrical resistance of dilute copper alloys at very low temperatures. G. K. WHITE. *Canad. J. Phys.*, **33**, No. 3–4, 119–24 (March–April, 1955).

An adiabatic demagnetization cryostat for the measurement of electrical resistance of metals is described. Some preliminary results on copper containing small amounts of iron and tin are reported. These indicate that the rise in electrical resistance below the minimum is essentially complete in these specimens by $\sim 2^\circ K$.

A.

537.311.31 : 548.7

3718. Electrical resistivity minimum and structural defects in copper. R. W. SCHMITT AND M. D. FISKE. Letter in *Phys. Rev.*, **96**, No. 5, 1445–6 (Dec. 1, 1954).

Experiments on high-purity copper after various degrees of cold work and heat treatments indicate no effect of these variables, and therefore no effect of crystal boundaries, on the resistivity minimum. There is a definite difference between remelted samples and those only recrystallized.

W. M. LOMER

537.311.31 : 548.7

3719. Electrical resistivity minimum reported in copper-zinc alloys. R. W. SCHMITT. Letter in *Phys. Rev.*, **96**, No. 5, 1446–7 (Dec. 1, 1954).

Experiments on dilute alloys of Zn in high-purity Cu failed to detect any marked resistivity minimum, contradicting reports by other workers. There are indications that “pure” copper which has been through the alloying process without the deliberate addition of any alloying elements differs from the original stock. This is attributed to the picking up of minimum-producing impurity in the melting process.

W. M. LOMER

537.311.32 : 537.323

3720. Electrical conductivity and thermo-electric motive force in MgO single crystal. E. YAMAKA AND K. SAWAMOTO. *J. Phys. Soc. Japan*, **10**, No. 3, 176–9 (March, 1955).

Electrical conductivities of MgO single crystals were measured by an a.c. method from $650^\circ C$ to $1000^\circ C$. Curves of $\log \sigma$ v. $1/T$ have the slope of

2.3 eV. Specific resistivities of magnesium-coloured samples are smaller than those of uncoloured and oxygen-coloured samples, so that it may be concluded that charge carriers originate from impurity levels of oxygen vacancies or interstitial magnesium atoms. The measurements of sign of thermoelectric motive force showed that charge carriers are electrons in all samples. The values of T.E.M.F. are from 0.1 mV/deg to 10 mV/deg at various concentrations of excess magnesium. A.

537.311.32 : 548.7

3721. On the resistivity and crystal structure of binary oxide of nickel and cobalt. T. SAKATA, K. SAKATA AND K. KIGOSHI. *J. Phys. Soc. Japan*, **10**, No. 3, 179–86 (March, 1955).

A solid solution MeO (Me = Ni, Co₂) was prepared by quenching the specimens derived from mixture of nickel and cobalt carbonates from a temperature higher than 850°C. The resistivity measurement during the heat treatment provided a convenient measure of the phase change. MeO shows a high resistivity at room temperature and has a NaCl-type crystal structure with lattice parameter of 4.23 Å. Its resistivity could be lowered by heat treatment, and its lowering was found to accompany shrinkage of lattice parameter and increase in oxygen content without appreciable change in crystal form. The conduction mechanism in MeO having low resistivity may be considered to be the same as in the case of black nickel oxide, except that the degree of oxygen excess can amount to several per cent in the former case. The phase change in MeO caused by the heat treatment was also investigated, in comparison with the case of pure cobalt and nickel oxides and the effect of mixing was discussed. A.

537.311.33

3722. On the conductivity of non-polar crystals in the strong electric field. I. J. YAMASHITA AND M. WATANABE. *Progr. theor. Phys.*, **12**, No. 4, 443–53 (Oct., 1954).

Recently Ryder and Shockley have found experimentally that the electrical conduction in a pure germanium crystal shows marked deviation from Ohm's law in a strong electric field. In order to clarify these phenomena on the usual theory of electrical conduction, the authors have calculated the distribution function of conducting electrons in a non-polar semiconductor by solving the well-known Bloch integral equation to second-order approximation, taking account of the interaction of electrons with both the acoustical and optical modes of lattice vibrations. As a result they have found that their theory may well interpret the general behaviour of this phenomenon qualitatively. They have also discussed the effect of impurity ions upon the critical field strength. A.

537.311.33

3723. Surface barriers and surface conductance. J. BARDEEN AND S. R. MORRISON. *Physica*, **20**, No. 11, 873–84 (Nov., 1954).

Reviews briefly the effect of a space-charge barrier layer at the free surface of a semiconductor on various properties: (1) contact potential, (2) change in contact potential with illumination, $(\Delta C.P.)_L$, (3) rectifica-

tion, (4) electron transfer reactions, including adsorption, (5) surface life-time and photoconductivity, (7) surface conductance, including the channel effect in *npn* transistors, (8) effect of an external transverse electric field on surface conductance (field effect). Recent measurements made at Illinois of changes of surface conductance of germanium with ambient are described. Ambients were changed in a cycle similar to that used by Brattain: sparked O₂, dry O₂, wet O₂, dry O₂. These measurements combined with calculations of surface conductance by J. R. Schrieffer enable one to estimate the height of the surface barrier and the way the height changes with ambient. Changes of the order of 0.3 eV are found. An inversion layer of *p*-type conduction on an *n*-type sample is frequently observed with sparked O₂ and dry O₂. Simultaneous measurements of photoconductivity, $(\Delta C.P.)_L$, and of the field effect enable one to correlate these quantities with the barrier. The field effect changes sign when the surface conductance is a minimum. Effective mobility of the induced charge is less than the theoretical maximum. A.

537.311.33

3724. Electrical properties in cubic semiconductors with spheroidal energy surfaces. M. SHIBUYA. *Physica*, **20**, No. 11, 971–5 (Nov., 1954).

Discrepancies between the "scalar effective mass" theory and the magnetoresistance results of Pearson and Suhl for germanium are explained by assuming several spheroidal energy surfaces in the Brillouin zone and developing a modified formal theory of conductivity using the "tensor effective mass." The electrical properties of germanium are satisfactorily explained with the exception of the dielectric constant at microwave frequencies for *n*-type crystals.

G. F. J. GARLICK

537.311.33

3725. Thermal scattering of electrons in semiconductors. C. ENZ. *Physica*, **20**, No. 11, 983–5 (Nov., 1954).

An attempt to explain the discrepancy in the variation of mobility with temperature between theory and experiment, based on the usual spherical energy surfaces but allowing for multi-phonon processes.

C. A. HOGARTH

537.311.33

3726. Heat conductivity of semiconductors. D. TER HAAR AND A. NEAVES. *Physica*, **20**, No. 11, 995–6 (Nov., 1954).

Calculates the electronic heat conductivity and the lattice contribution. For temperatures well above the Debye temperature the ratio of electronic to lattice conductivity is of order 10^{-4} .

C. A. HOGARTH

537.311.33

3727. Heat conduction in semi-conductors. G. BUSCH AND M. SCHNEIDER. *Physica*, **20**, No. 11, 1084–6 (Nov., 1954).

InSb has a high thermal conductivity *K* and shows a minimum at about 80°C. *K* plotted as $f(1/T)$ gives a straight line for low temperatures. If this line representing the lattice contribution is extrapolated to high temperatures, the difference from the observed curve gives the apparent electronic contribution *K_e* to

K. A plot of $\log K_e v. 1/T$ gives a straight line of slope 0.13 eV corresponding to an activation energy of 0.26 eV in good agreement with Welker's value for the value at $T = 0^\circ\text{K}$. K_e is, however, larger (about 100 $\times$) than one would expect from the Wiedemann-Franz law.

C. A. HOGARTH

537.311.33

3728. Remark on the paper by Prof. G. Busch. H. FRÖHLICH AND C. KITTEL. *Physica*, 20, No. 11, 1086 (Nov., 1954).

See preceding abstract. In the theory of the electronic contribution to the thermal conductivity of semiconductors in the intrinsic range the transport of ionization energy E must not be neglected. This increases the usually calculated K_e by $(E/kT)^2$ which may be 100 or more in some materials, and this fact may resolve the difficulty pointed out by Busch.

C. A. HOGARTH

537.311.33

3729. Thermo-electric power in semi-conductors. D. K. C. MACDONALD. *Physica*, 20, No. 11, 996-8 (Nov., 1954).

The concept of phonon-electron scattering suggests that electrons are swept along by the lattice waves and may give an additional component of thermoelectric power. The phenomenon is analysed from direct momentum considerations. The results indicate the need for thermoelectric power measurements in the helium range so as to distinguish between the various processes.

C. A. HOGARTH

537.311.33

3730. Use of an effective mass in semiconductors. J. FRIEDEL. *Physica*, 20, No. 11, 998-1001 (Nov., 1954) In French.

Theoretical. Discusses the usefulness of the concept of effective mass in two approaches to the perturbed lattice. It is useful for conduction electrons when the perturbation is slowly varying, but not for impurity levels, where the approach of Tibbs (1939), using the true mass, is preferred.

J. HAWGOOD

537.311.33

3731. Fluctuations in the number of charge carriers in a semiconductor. R. E. BURGESS. *Physica*, 20, No. 11, 1007-10 (Nov., 1954).

It is shown that the thermodynamic and statistical approaches to the fluctuations of carrier population in intrinsic, near intrinsic and strongly n -type semiconductors lead to the same result. However, it is also shown that for large concentrations of electrons or holes Gaussian conditions hold giving distributions for fluctuations with smaller variances than those for Poisson or binomial forms usually assumed.

G. F. J. GARLICK

537.311.33

3732. Surface recombination as a function of the concentration of charge carriers in the interior. B. H. SCHULTZ. *Physica*, 20, No. 11, 1031-3 (Nov., 1954).

The surface recombination velocity of germanium has been studied by determining the relaxation time of the photoconductance of thin rods which were illuminated periodically. The dependence of the recombination velocity on the concentration of charge carriers in the interior is then discussed.

P. T. LANDSBERG

537.311.33

3733. A flying light spot method for simultaneous determination of lifetime and mobility of injected current carriers. G. ADAM. *Physica*, 20, No. 11, 1037-41 (Nov., 1954).

A modification of the light spot method [Abstr. 4379 (1951)] is described in which a rotating mirror system causes the light spot to move over the probe on the crystal surface at velocities of 600-4000 cm/sec. The resultant photosignal is displayed on an oscilloscope and from the different rates of rise and decay of the signal, the diffusion constant and the lifetime of the injected carriers can be determined independently of one another.

D. G. AVERY

537.311.33

3734. Surface recombination and the floating junction. A. R. MOORE AND W. M. WEBSTER. *Physica*, 20, No. 11, 1046-50 (Nov., 1954).

On the simplifying assumption that the excess hole concentration is small in a n -type Ge base, a formula is deduced giving the total voltage as a function of the floating potential (i.e. the potential at the junction between the base and a layer of p - or n -type Ge). This formula agrees with experiment. The drift time for a pulse of electron holes to travel through a p -layer is found to be negligible; diffusion methods for measurement of this time gave spuriously high values because of the effect of inversion layers, which are difficult to remove. It is therefore suggested that the pulse method is to be preferred.

N. CORCORAN

537.311.33

3735. The variation of point contact injection ratio with emitter current. P. C. BANBURY AND J. HOUGHTON. *Physica*, 20, No. 11, 1050-3 (Nov., 1954).

Theory predicts that the injection ratio γ should decrease with increasing emitter current. This behaviour is found for tungsten emitter contacts on five specimens of n -type Ge.

C. A. HOGARTH

537.311.33

3736. Potential barriers in low angle grain boundaries. R. K. MUELLER. *Physica*, 20, No. 11, 1053-8 (Nov., 1954).

Grain boundaries in germanium present a high resistance to current flow up to a given voltage when a breakdown occurs. For a small-angle ($\frac{1}{2}^\circ$) boundary consisting of a periodic array of line charges associated with the edge dislocations, the structure of the barrier is calculable and the breakdown conditions can be deduced.

C. A. HOGARTH

537.311.33

3737. Energy levels in semi-conductors computed from Debye absorption at radio-frequencies. R. FREYMAN. *Physica*, 20, No. 11, 1115-17 (Nov., 1954).

The Debye absorption for r.f. fields on semiconductors is used to determine the activation energy of crystal lattice imperfections in monatomic solids (B and Se) and in oxides.

G. F. J. GARLICK

537.311.33

3738. Chemical binding and semiconductor properties. H. KREBS. *Physica*, 20, No. 11, 1125-9 (Nov., 1954) In German.

The electrical properties of the half-metals, As, Sb,

Bi, are explained by considering the double-sided character of the extension in space of p -electrons. It is shown that the p -electron system in PbS is analogous to the π -electron systems of organic compounds.

W. GOOD

537.311.33

3739. Nuclear magnetic relaxation in semiconductors. N. BLOEMBERGEN. *Physica*, **20**, No. 11, 1130-3 (Nov., 1954).

Nuclear spin relaxation times of 10^2 to 10^5 sec may arise through the simultaneous flip of conduction electrons in semiconductors and explicit formulae are given for Fermi-Dirac and for Maxwell-Boltzmann statistics. At paramagnetic impurity centres the relaxation is faster and when these are present diffusion of nuclear spins to these centres may be the controlling feature.

D. H. WHIFFEN

537.311.33

3740. The nature of the insulating layers in ferromagnetic semiconductors. R. PARKER. Letter in *Physica*, **20**, No. 12, 1314-15 (Dec., 1954).

Some ferromagnetic semiconductors exhibit a strong dispersion in their a.c. resistivity and dielectric properties in the audiofrequency range. This is attributed to thin surface layers of high resistivity which in turn are due to regions in the material which are not spontaneously magnetized. Resistivity and magneto-resistance measurements on manganites support this explanation.

A. E. DE BARR

537.311.33

3741. Ionization and solubility in semiconductors. H. REISS AND C. S. FULLER. Letter in *Phys. Rev.*, **97**, No. 2, 559-60 (Jan. 15, 1955).

A relation is given relating donor and acceptor concentrations, an equilibrium constant and the intrinsic carrier concentration, and is verified by means of measurements on Li-doped Si crystals. A comparison of calculated and experimental solubility-temperature curves for Li in Si is given showing fair agreement.

C. A. HOGARTH

537.311.33

3742. Motion of electrons and holes in perturbed periodic fields. J. M. LUTTINGER AND W. KOHN. *Phys. Rev.*, **97**, No. 4, 869-83 (Feb. 15, 1955).

A new method of developing an "effective-mass" equation for electrons moving in a perturbed periodic structure is discussed. This method is particularly adapted to such problems as arise in connection with impurity states and cyclotron resonance in semiconductors such as Si and Ge. The resulting theory generalizes the usual effective-mass treatment to the case where a band minimum is not at the centre of the Brillouin zone, and also to the case where the band is degenerate. The latter is particularly striking, the usual Wannier equation being replaced by a set of coupled differential equations.

A.

537.311.33

3743. Semiconducting intermetallic compounds. H. WELKER. *Physica*, **20**, No. 11, 893-909 (Nov., 1954).

Reviews what is known about these materials as well as describing recent work on the III-V compounds in the author's own laboratory. Mg_2Si , Mg_2Ge , Mg_2Sn , Mg_2Pb are briefly referred to as well as

Mg_3Sb_2 , $ZnSb$, $CdSb$, Bi_2Te_3 , PbS , $PbSe$, $PbTe$, FeS_2 and MnS_2 . Other semiconducting compounds are of interest since they may be referred to Group IV materials, e.g. $GaAs$, $ZnSe$, $CuBr$, $InSb$, $CdTe$, and so on. In all these cases the material has the zinc blende structure. The variation of electrical properties may be explained by the increase in ionic contribution to the bonding as we pass from Group IV to III-V to II-VI to I-VII compounds. The properties of $InSb$, $InAs$, InP , $GaSb$, $GaAs$, $AlSb$ are summarized and comparative data are tabulated for comparison with Si and Ge.

C. A. HOGARTH

537.311.33

3744. New semiconducting compounds of diamond type structure. C. H. L. GOODMAN AND R. W. DOUGLAS. *Physica*, **20**, No. 11, 1107-9 (Nov., 1954).

A discussion of the different types of bonding possible in binary, ternary and quaternary compounds with a ZnS structure, and the effect of the bond type on the energy gap and carrier mobility.

A. E. DE BARR

537.311.33

3745. Semiconducting properties of mixed crystals with perovskite structure. G. H. JONKER. *Physica*, **20**, No. 11, 1118-22 (Nov., 1954).

Dependence of semiconduction on composition and on temperature is determined for the systems $(La_xSr_{1-x})(Mn^{3+}_xMn^{4+}_{1-x})O_3$, $(La_xSr_{1-x})(Fe^{3+}_xFe^{4+}_{1-x})O_3$ and for $(La, Ba)(Cr, Fe)O_3$, $(La, Ba)(Mn, Fe)O_3$ and $(La, Ba)(Mn, Cr)O_3$. A phase diagram for $(La, Sr)(Cr, Mn, Fe)O_3$ indicates composition zones for conduction predominantly due to electron motion on Mn, Cr or Fe ions respectively. Full discussion of results is included.

G. F. J. GARLICK

537.311.33 : 539.185

3746. Changes in the electrical properties of graphite due to neutron irradiation. G. H. KINCHIN. *J. nuclear Energy*, **1**, No. 2, 124-9 (Dec., 1954).

The lattice defects produced in graphite by neutron irradiation give rise to additional scattering and the trapping of electrons. A simple theory is adequate to explain the changes, and both the scattering mean free path and number of electrons trapped have been calculated.

A.

537.311.33 : 621.316.86

3747. Loading noise of carbon film resistors. K. LUNZE. *Wiss. Z. Tech. Hochsch. Dresden*, **3**, No. 5, 711-26 (1953-54) In German.

Semiconductors, amongst which can be included carbon films, exhibit noise voltages which are additional to Nyquist noise and dependent upon the current loading. Based on the assumption that this noise arises from equal variations of the resistance of single cells, occurring randomly, an expression, loading noise factor = k (current density)², is derived. A simple substitution method of checking this formula is described and its validity confirmed. Detailed investigations into the wide distribution of the value of the noise factor for any definite resistance value showed that its range could be reduced to 1 : 3 when differences in dimensions and manufacturing processes were taken into account. The effects of frequency, moisture, base surface and method of application of the protecting lacquer are studied.

H. G. M. SPRATT

537.311.33

3748. On the electrical conductivity of cadmium selenide. K. HAUFFE AND H. G. FLINT. *Ann. Phys. [Leipzig]* **15**, No. 3-4, 141-7 (1955) In German.

As a means of explaining the processes taking place when CdSe is formed during the pre-treatment of Se rectifiers the dependence of electrical conductivity σ on the Cd and Se partial pressures of CdSe in the temperature range 300 to 500°C was measured. Above $P_{Cd} = 10^{-1}$ atm, $\sigma \propto P_{Cd}^{1/4.5}$ and below this σ is practically independent. For $P_{Se} < 10^{-2}$ atm σ is independent of P_{Se} while above this pressure $\sigma \propto P_{Se}^{-1/2}$. The effects of small admixtures of Tl_2Se are measured and discussed in terms of disorder theory.

C. A. HOGARTH

537.311.33

3749. Resistivity, Hall effect and thermo-electric power of conducting and photoconducting single crystals of CdS from 20-700°K. F. A. KRÖGER, H. J. VINK AND J. VOLGER. *Physica*, **20**, No. 11, 1095-9 (Nov., 1954).

For reduced or Cl-doped CdS the variation of Hall effect with temperature indicates conduction in a donor level band as well as in the conduction band. Photoconducting and semiconducting crystals show an increase in resistance and Hall effect at high and low temperatures due to hole motion at high temperatures and trapping processes at low temperatures.

G. F. J. GARLICK

537.311.33

3750. Optical variation of the contact potential of cadmium sulphide. G. WLÉRIK. *Physica*, **20**, No. 11, 1099-103 (Nov., 1954) In French.

The contact potential is found by using a beam of slow electrons incident on a CdS crystal *in vacuo* and measuring the current v . voltage curves for the system and without illumination. Results for strong illumination (red or blue light) can be explained by shift of the Fermi level in the crystal by light excitation; assumption of surface states is not necessary.

G. F. J. GARLICK

537.311.33

3751. On photochemical reactions in single crystals of CdS. K. W. BÖER. *Physica*, **20**, No. 11, 1103-7 (Nov., 1954) In German.

Photoconduction in CdS is investigated at high temperatures. On excitation the photocurrent rises and then falls off due to structural changes in the crystals. The changes increase in rate with light intensity. A tentative discussion of the results is given particularly with reference to nature of non-radiative recombinations in these crystals.

G. F. J. GARLICK

537.311.33

3752. Temperature dependence of the Hall effect and the resistivity of CdS single crystals. F. A. KRÖGER, H. J. VINK AND J. VOLGER. *Philips Res. Rep.*, **10**, No. 1, 39-76 (Feb., 1955).

The d.c. dark-conductivity and the Hall effect have been measured with single crystals of CdS, pure and doped with Cl and Ga, from 25 to 700°K. Peaks in the curves of the Hall constant as a function of the temperature indicate a double-band conduction mechanism. Analysis of the results shows that the data can best be interpreted by assuming conduction in a

donor band in addition to that in the normal conduction band. In all cases electrons are found to be the current-carriers. At room temperature the electron mobility in the normal conduction band, limited by thermal scattering, is found to be $\mu_c \approx 210 \text{ cm}^2/\text{V sec}$. The mobility in the donor band is found at low temperatures. It increases both with the concentration of donors and with the number of electrons. Thermo-electric-power data at room temperature and the variations of the Hall constant with temperature can be explained by an effective electron-mass ratio $m^*/m_0 \approx 0.2-0.3$. The depth of donor levels below the conduction band in CdS-Cd and CdS-Cl is 0.01-0.02 eV at low carrier concentrations, and decreases to zero at concentrations exceeding 10^{18} cm^{-3} . For insulating crystals, the conductivity and the Hall effect were measured upon illumination with the green mercury line (0.5 W/cm^2). Irradiation with infrared in addition is found to cause a decrease in the concentration of free electrons present under stationary conditions. Capacity measurements with insulating crystals lead to a value of the static dielectric constant $\epsilon_s = 11.6 \pm 1.5$. The temperature variation of the electron mobility as limited by lattice scattering between 200 and 700°K can be quantitatively accounted for with $m^*/m_0 = 0.2-0.3$, a characteristic temperature of longitudinal optical modes $\Theta_o = 250-300^\circ\text{K}$, and a scattering at acoustical modes $aT^{-3/2}$ with $a = 3-8 \times 10^6 \text{ cm}^2 \cdot \text{degree}^{3/2}/\text{volt. sec}$. A.

537.311.33

3753. On some semiconducting properties of cuprous oxide. C. FRITZSCHE. *Ann. Phys. [Leipzig]* **15**, No. 3-4, 178-81 (1955) In German.

Conductivity measurements on Cu_2O disks, prepared at various temperatures and O_2 pressures with subsequent variable cooling, indicate that the regions of stability of Cu_2O are of importance and not the concentration of impurities. An anomaly of the capacity of such a rectifier, which may be connected with this, is described.

F. ANSBACHER

537.311.33

3754. Diffusion constant of carriers in germanium. A. MANY. *Physica*, **20**, No. 11, 985-9 (Nov., 1954).

A method of measuring the diffusion constant D by means of injection into a rectangular filament, applying a sweeping field, measuring the carrier lifetime τ for the specimen as it is gradually decreased in size, and thus calculating the effect of diffusion in directions perpendicular to the sweeping field. τ was measured by the Many bridge (1954) technique. D and the injection ratio were examined as functions of temperature.

C. A. HOGARTH

537.311.33

3755. The photo-electro-magnetic effect in germanium and lead sulphide. T. S. MOSS. *Physica*, **20**, No. 11, 989-93 (Nov., 1954).

Reviews experimental results and outlines the theory.

C. A. HOGARTH

537.311.33

3756. Galvano-magnetic effects in germanium at high frequencies. B. DONOVAN AND G. REICHENBAUM. *Physica*, **20**, No. 11, 993-5 (Nov., 1954).

Measurements of Hall effect up to 3 Mc/s show no variation from the d.c. value.

C. A. HOGARTH

- 537.311.33
3757. Thermal acceptors in germanium. R. J. HODGKINSON. *Physica*, 20, No. 11, 1001-5 (Nov., 1954).

Discussion of the temperature dependence of the solid solubility of Cu in Ge, comparing qualitative predictions from free energy/composition curves with experimental results from thermal acceptor studies. The solubility curve can be predicted with reasonable accuracy, given two points on it. J. HAWGOOD

- 537.311.33
3758. Acceptor activity of copper in *n*- and *p*-type germanium of different resistivity. F. VAN DER MAESSEN AND J. A. BRENNMAN. *Physica*, 20, No. 11, 1005-7 (Nov., 1954).

This was studied to determine the effect of the Fermi level on the change in the number of acceptor levels produced by saturating Ge with Cu. Consequences of the production by Cu of acceptor levels of two different energies are discussed; the hypothesis that each Cu atom produces just two levels is rejected. J. HAWGOOD

- 537.311.33
3759. Light emission from injecting contacts on germanium in the 2μ to 6μ band. P. AIGRAIN. *Physica*, 20, No. 11, 1010-13 (Nov., 1954).

By using germanium crystals shaped to give Weierstrass spheres with injection at the Weierstrass point infrared emission due to carrier injection is detected in the $2-6\mu$ region in spite of the high refractive index which normally causes trapping of the radiation in the crystal. Intensity of emission rises from 2μ to 6μ with no maximum. G. F. J. GARLICK

- 537.311.33
3760. Measurement of surface recombination on germanium. H. K. HENISCH, W. N. REYNOLDS AND P. M. TIPPLe. *Physica*, 20, No. 11, 1033-7 (Nov., 1954).

Surface recombination velocities (s) have been measured by a pulse method for a thin filament of germanium and been related experimentally to the steady-state photoconductance of the same filament under steady illumination. The use of the photoconductive method of measuring s is discussed in the light of these experiments. P. T. LANDSBERG

- 537.311.33
3761. Measurements of the recombination velocity at germanium surfaces. D. T. STEVENSON AND R. J. KEYES. *Physica*, 20, No. 11, 1041-6 (Nov., 1954).

The surface recombination velocity (s) was measured for *n*- and *p*-type Ge in wet and dry O_2 at different temperatures (T). On the hypotheses that (a) the number of trapping levels per cm^2 and their energy are both independent of the temperature and of the ambient, and (b) the charge on the outside of the oxide layer depends only on the ambient, the graph of $\log sT$ against $1/T$ is a straight line for *n*-Ge. This was found experimentally to be the case. For *p*-Ge, the observed values, while not linear, agree with the above hypotheses. N. CORCORAN

- 537.311.33
3762. Carrier extraction in germanium. A. F. GIBSON. *Physica*, 20, No. 11, 1058-9 (Nov., 1954).

The change in conductivity of near intrinsic *n*-type

material by carrier extraction was determined, and the technique applied to extend drift mobility measurements into the intrinsic conduction range. J. FRANKS

- 537.311.33
3763. Breakdown effect in *p-n* alloy germanium junctions. R. D. KNOTT, I. D. COLSON AND M. R. P. YOUNG. Note in *Proc. Phys. Soc. [London] B*, 68, Pt 3, 182-5 (March, 1955).

Calculations predict that for the resistivity ρ of *n*-type Ge $> 0.5 \text{ ohm.cm}$ avalanche breakdown is expected and for $\rho < 0.5 \text{ ohm.cm}$ field emission breakdown is expected. Experimental results agree well. C. A. HOGARTH

- 537.311.33
3764. Some properties of gallium arsenide. R. BARRIE, F. A. CUNNEL, J. T. EDMOND AND I. M. ROSS. *Physica*, 20, No. 11, 1087-90 (Nov., 1954).

Specimens of GaAs, prepared by heating the elements together in stoichiometric ratio, were all *n*-type, minimum carrier density $2.5 \times 10^{17} \text{ cm}^{-3}$. Turnover voltages at a point contact ranged from 10 to 150 V. Optical data give an energy gap of 1.35 eV, compared with 1.25 eV from photoconductivity measurements. An effective mass ratio for electrons of 0.03 is deduced from thermoelectric data. J. FRANKS

- 537.311.33
3765. On the semiconducting properties of gallium phosphide. O. G. FOLBERTH AND F. OSWALD. Note in *Z. Naturforsch.*, 9a, No. 12, 1050-1 (Dec., 1954) In German.

Absorption measurements lead to the relation $\Delta E = 2.4 - 5.5 \times 10^{-4}T$ (eV) for the variation between energy gap and temperature. In the visible region the refractive index n is 3.37 and the dispersion is high; in the infrared n is 2.9 and the dispersion is very small. C. A. HOGARTH

- 537.311.33
3766. On the intermetallic compounds indium antimonide, gallium antimonide and aluminium antimonide. R. G. BRECKENRIDGE, R. F. BLUNT, W. R. HOSLER, H. P. R. FREDERIKSE, J. H. BECKER AND W. OSHINSKY. *Physica*, 20, No. 11, 1073-6 (Nov., 1954).

Electrical conductivity and Hall coefficient, and the absorption spectra have been measured as functions of temperature for several samples. InSb shows anomalous semiconducting behaviour, GaSb has no striking peculiarities, and AlSb seems to possess impurity states in the forbidden band due to lattice disorder. C. A. HOGARTH

- 537.311.33
3767. The interpretation of Hall effect, conductivity and infra-red measurements in indium antimonide. I. G. AUSTIN AND D. R. MCCLYMONT. *Physica*, 20, No. 11, 1077-83 (Nov., 1954).

Published data for the temperature variation show that the curves do not coincide exactly in the "intrinsic" region. Discussion of the properties follows a similar line to that of Tanenbaum and Maita [Abstr. 8410 (1954)], but there is no requirement to assume the correctness of a particular mobility law at high temperatures. C. A. HOGARTH

537.311.33
3768. The electrical properties of indium arsenide. II. O. G. FOLBERTH, O. MADELUNG AND H. WEISS. *Z. Naturforsch.*, 9a, No. 11, 954-8 (Nov., 1954) In German.

For previous work, see Abstr. 2431, 11057 (1954). Results from measurements of conductivity and Hall effect on five *n*-type and two *p*-type samples. The width of the energy gap at absolute zero is found to be 0.47 eV. At room temperature the electron mobility is 30 000 cm²/V sec whilst the hole mobility is not likely to exceed 200 cm²/V sec. For the geometric mean of the effective masses of electrons and holes the value 0.1 is found.

A. E. DE BARR

537.311.33
3769. The electronic and optical properties of the lead sulphide group of semi-conductors. R. A. SMITH. *Physica*, 20, No. 11, 910-29 (Nov., 1954).

Reviews the properties of PbS, PbSe and PbTe, well known as photoconductors. There has been much confusion over the values of the energy gaps ΔE for these materials and the means of determining this quantity unambiguously is discussed fully. A new method of extrapolating the absorption curves to zero absorption is described. Methods of analysing Hall effect and conductivity data so as to give results for ΔE consistent with optical values are compared and good agreement can be obtained with few arbitrary assumptions. The determination of non-equilibrium properties such as carrier lifetime is discussed and the Auger effect provides an explanation for the observed results on recombination and lifetime. The processes taking place in layer photocells are still not properly understood. C. A. HOGARTH

537.311.33

3770. The preparation and electrical properties of lead sulfide crystals. W. W. SCANLON AND R. F. BREBRICK. *Physica*, 20, No. 11, 1090-2 (Nov., 1954).

The rate of diffusion of S into PbS crystals, exposed to a range of pressures of S vapour, was obtained from measurements of the motion of *p-n* boundaries, the diffusion coefficient is 2×10^{-6} cm²/sec. *p*-type and *n*-type crystals thus treated contained 10^{16} – 10^{19} carriers/cm³. The intrinsic activation energy is 0.34 eV, the resistivity of intrinsic material is estimated at about 3 ohm.cm at room temp.

J. FRANKS

537.311.33

3771. On the chemical reactions during oxidation of lead sulphide by atmospheric oxygen and their relation to the electrical conductivity and photoconductivity of lead sulphide layers. B. REUTER AND R. STEIN. *Physica*, 20, No. 11, 1092-5 (Nov., 1954) In German.

The action of dry and moist O on PbS at various temperatures is discussed. In the presence of excess Pb, rapid oxidation takes place at room temperature with marked changes in conductivity, no such effects occur with excess S. From considerations of reactions at higher temperatures it is concluded that S rather than O affects the conductivity. Photoconduction occurs at a certain stage in the oxidation process, probably during a reaction between PbO and S.

J. FRANKS

537.311.33

3772. Magneto-resistance effect and the band struc-

ture of single crystal silicon. G. L. PEARSON AND C. HERRING. *Physica*, 20, No. 11, 975-8 (Nov., 1954).

The electrical conductivity in oriented single crystals of both *n*- and *p*-type silicon has been studied as a function of magnetic field strength, direction of magnetic field, direction of electric current and temperature. The results are discussed in terms of the ratio of magneto-resistance mobility to Hall mobility and of the shape of the energy surfaces.

A. E. DE BARR

537.311.33

3773. Hyperfine splitting of donor states in silicon. W. KOHN AND J. M. LUTTINGER. *Phys. Rev.*, 97, No. 4, 883-8 (Feb. 15, 1955).

The hyperfine splitting of donor states in Si has been theoretically estimated. The results agree with the recent spin resonance experiments of Fletcher *et al.* within a factor of about 2, which is better than the estimated uncertainty of the calculation.

A.

537.311.33

3774. On the measurement of minority carrier lifetime in *n*-type silicon. J. B. ARTHUR, W. BARDLEY, A. F. GIBSON AND C. A. HOGARTH. *Proc. Phys. Soc. [London] B*, 68, Pt 3, 121-9 (March, 1955).

A number of methods has been devised in the past few years for measuring the lifetime of minority carriers in semiconductors. With germanium all these methods give results consistent with each other. When another semiconductor, namely silicon, is studied quite large differences in the results from different methods are found. These discrepancies are described and their origin discussed. It is concluded that an uncritical application of well-established germanium technology to any other semiconductor may lead to erroneous conclusions.

A.

537.311.33

3775. Some electrical properties of the semiconducting tellurium compounds In₂Te₃, CdTe and Ag₂Te. J. APPEL AND G. LAUTZ. *Physica*, 20, No. 11, 1110-14 (Nov., 1954) In German.

Conductivity/temperature plots lead, for In₂Te₃, to activation energies of 0.84–1.02 eV below about 600°K and 2.3–2.5 eV above. For CdTe the values are 0.73–0.78 eV below about 400°K and 1.43–1.57 eV over about 400–600°K (or higher for some specimens), and at least two other ranges of activation energy, possibly associated with chemical changes, are also evident. For Ag₂Te a phase-change occurs at about 423°K: the low-temp. β -modification has nearly-constant high conductivity of about 10^3 mho.cm⁻¹ down to 60°K (but specimens of lower conductivity at 300°K show marked decreases at 80–60°K); the high-temp. α -modification has lower conductivity. Hall constant, Hall mobility (~ 4000 cm².volt⁻¹.sec⁻¹ below 300°K) and magneto-resistance curves are also given for Ag₂Te.

F. F. ROBERTS

537.311.33

3776. Properties of metal to germanium contacts. C. V. BOCCIARELLI. *Physica*, 20, No. 11, 1020-5 (Nov., 1954).

The contacts were formed by first electrolytically etching the Ge surface and then immediately plating

the surface with the required metal. In most cases electrolytic plating was used, but in a few instances vacuum evaporation was employed. Contacts with repeatable characteristics could be produced. The rectification characteristics of Ge-In contacts made in this way agree closely with a theory which assumes that the hole-current is predominant, and that the lifetime was infinite. Furthermore it was found that the saturated reverse currents were largely independent of the metals used, suggesting that the rectification effects are more a property of the etched Ge surface than of the metal-Ge interface, and that the method might prove a powerful means of investigating surface conditions in semiconductors. D. G. AVERY

537.311.33

3777. An evaluation of surface recombination current in fused impurity junction transistor. J. LAPLUME. *Physica*, **20**, No. 11, 1029–31 (Nov., 1954).

A theoretical study of a hemispherical emitter of radius a separated by a short distance from a hemispherical collector of radius c . The emitter current, recombination current and current gain are discussed as a function of the ratio a/c . P. T. LANDSBERG

537.311.33

3778. The barrier height of point-contact germanium diodes inferred from measurements of the voltage dependence of capacitance. F. F. ROBERTS AND J. R. TILLMAN. Note in *Proc. Phys. Soc. [London] B*, **68**, Pt 2, 113–15 (Feb., 1955).

Results on several commercial diodes measured at 1.2 Mc/s. If the barrier heights are estimated from the results, values considerably lower than those obtained from measurements of injection ratio are obtained. C. A. HOGARTH

537.311.33 : 621.3.014.33 : 621.314.63

3779. Anomalous forward switching transient in p - n junction diodes. N. T. JONES, R. H. KINGSTON AND S. F. NEUSTADTER. *J. appl. Phys.*, **26**, No. 2, 210–13 (Feb., 1955).

A delay in the flow of forward current when a grown-crystal p - n junction diode is switched from reverse to forward bias is explained on the basis of an extra p - n barrier in the grown-crystal bar. This effect was observed in 10 out of 24 production units, while no such anomaly was found in fused-junction diodes. A mathematical theory of the effect gives good agreement with the experimental results. A.

537.312 : 539.16 : 621.3.011.22 : 621.319.35

3780. The internal resistance of the radioactive converter. O. RIEDEL. *Z. Elektrochem.*, **58**, No. 8, 641–3 (1954) In German.

The convertor comprises a capacitor with one plate coated with a β -emitter and it is shown that the current/voltage characteristic is very non-linear and that the current decreases with increasing voltage. It is suggested that some of the new β -emitters produced in nuclear fission will make it possible to use a convertor as a stabilizer in v.h.v. circuits.

J. M. HOUGH

537.312.5

3781. On the photoelectric properties of evaporated cadmium sulphide. W. VEITH. *Z. angew. Phys.*, **7**, No. 1, 1–7 (1955) In German.

Detailed description of the sensitization procedures

of CdS photoconductive cells of high sensitivity is given. Measurements of time constant, spectral response and on cells with admixtures of impurity metals are described, and a discussion of the photoconduction mechanism is given. C. A. HOGARTH

537.312.5

3782. Photoconductivity in calcium tungstate. J. R. COOK. *Proc. Phys. Soc. [London] B*, **68**, Pt 3, 148–55 (March, 1955).

In view of earlier contradictory published results on the photoconductivity of crystalline calcium tungstate, this effect has been examined using artificial single crystals and an intense ultraviolet source. Photoconductivity has been demonstrated, with a space charge build up of long relaxation time. This latter is probably linked with the long duration phosphorescence previously reported in this material. The evidence produced indicates that calcium tungstate is an intrinsic semiconductor with an activation energy of 2.1 eV. The photoconductive properties are in approximate agreement with the assumption of an exponential trap distribution if a variation of capture cross-section with temperature is postulated. A.

537.312.5

3783. The photo-electric properties of indium antimonide. J. TAUC AND A. ABRAHÁM. *Czech. J. Phys.*, **4**, No. 4, 478–85 (Nov., 1954).

A change of resistance or the formation of a voltage in mono- or polycrystalline samples of InSb due to illumination has been observed, the magnitudes of which increase with decreasing temperatures. It is demonstrated that this is a photoconductive effect, arising in the volume of the sample or at barriers due to non-homogeneities, and a photovoltaic effect. The spectral curves were measured with long-wave limits $\lambda_1 = 5.8 \mu$ at -155°C , $\lambda_2 = 6.7 \mu$ at -42°C . It is shown that these phenomena are caused by the transition of electrons from the valence-bond band to the conduction band under the influence of photons. The width of the band of forbidden energy values below room temperature was found to be $E_G = 0.24 - 2.4 \times 10^{-4} T (\text{eV})$. A.

537.312.5

3784. Directional photoeffect in PbS layers. G. SCHWABE. Note in *Z. Naturforsch.*, **9a**, No. 12, 1054–5 (Dec., 1954) In German.

Photovoltaic effects were measured with a point contact on PbS layers previously tempered in air at 500 to 620°C. The measured e.m.f. depended systematically on the direction of the incident light. Explanations based on distributed p - n junctions and the photodiffusion effect are offered. C. A. HOGARTH

537.312.5

3785. Directionally dependent photoeffect in PbS layers. G. SCHWABE. Note in *Z. Naturforsch.*, **10a**, No. 1, 78 (Jan., 1955) In German.

The effect of light on certain layer photocells is found to depend markedly on the direction from which the incident radiation comes. The results of experiments are explained as due to the photodiffusion effect (Dember, 1931) and to a distribution of p - n junctions in the layer. C. A. HOGARTH

537.312.5
3786. Photoconductance in tetracene-type crystals: theory of the spectral dependence. L. E. LYONS. Letter in *J. chem. Phys.*, **23**, No. 1, 220 (Jan., 1955).

Photoconduction response in anthracene or tetracene follows the crystal absorption spectrum closely even for thick specimens. It is concluded to be a surface effect the primary process being exciton production: only those excitons which reach the surface give rise to conduction. A theoretical expression for the current is developed. G. F. J. GARLICK

537.312.5
3787. Solar-blind ultraviolet multiplier phototubes. L. DUNKELMAN. Letter in *J. Opt. Soc. Amer.*, **45**, No. 2, 134-5 (Feb., 1955).

Photomultiplier tubes with Ni, Ta, Ag and oxidized Ni cathodes and with magnesium dynodes have been made (RCA) and characteristics measured. The tubes are very insensitive to sunlight but the quantum yield for shorter wavelengths is still rather low. Improvement appears possible for the tantalum cathode. G. F. J. GARLICK

537.312.5 : 535.33.07
Note on the use of photoconducting cells in spectroscopy. See Abstr. 3558

537.312.62
3788. The destruction of superconductivity of thin films by a magnetic field. A. V. GUREVICH. *Zh. ékspér. teor. Fiz.*, **27**, No. 2, 195-207 (1954) In Russian.

It is shown that the treatment of Ginsburg and Landau in applying their theory to this problem [Abstr. 1017 (1952)] is correct only for the parameter $\kappa = 0$, where $\kappa = \sqrt{2eH_c\lambda^2/\hbar c}$ (H_c = bulk critical field, λ = penetration depth). The correct formulae for non-vanishing κ are deduced and turn out to be practically identical with those for $\kappa = 0$ if the actual values of κ for Sn and In are used. It is pointed out that Zavaritski [Abstr. 1018, 7298 (1952)] used an unjustified approximation in deducing λ_0 from his thick-film data and that a correct application of the theory gives good agreement between λ_0 as deduced from both thick- and thin-film data. This re-evaluation gives $\lambda_0 = 6.5 \pm 0.6 \times 10^{-6}$ cm for Sn and $6.4 \pm 0.5 \times 10^{-6}$ cm for In. Closely similar values are deduced from Lock's data [Abstr. 7909 (1951)] for critical fields of thin films, though for Sn Lock obtained an appreciably lower value from the film magnetizations. D. SHOENBERG

537.312.62
3789. Theory of superconductivity. M. R. SCHAFFROTH. Letter in *Phys. Rev.*, **96**, No. 5, 1442 (Dec. 1, 1954).

If the total interaction between electrons is such that it produces resonant states of electron pairs one should expect, according to Abstr. 1849 (1955), the onset of superconductivity. H. LONDON

537.312.62
3790. Change of elastic constants in a superconductor. J. L. OLSEN. Letter in *Nature [London]* **175**, 37 (Jan. 1, 1955).

The change of rigidity modulus of a polycrystalline tin wire on destruction of superconductivity by a magnetic field has been observed as a function of

temperature T . The maximum change is of order 2 parts in 10^6 and the temperature variation of the change is approximately as $1 - (T/T_c)^4$.

D. SHOENBERG

537.312.62 : 536.631
3791. Exponential temperature dependence of the electronic specific heat of superconducting vanadium. W. S. CORAK, B. B. GOODMAN, C. B. SATTERTHWAITE AND A. WEXLER. Letter in *Phys. Rev.*, **96**, No. 5, 1442-4 (Dec. 1, 1954).

$C/\gamma T_c = 10.0 \exp(-1.52T_c/T)$, where C = electronic specific heat in the superconducting state, $\gamma = 21.5 \times 10^{-3}$ cal. mole⁻¹ degree⁻² = coefficient of the normal electronic specific heat, $T_c = 5.05^\circ\text{K}$ = transition temperature. The measurements cover the range $1 < T_c/T < 4.2$, which is larger than for any other previous measurements of C and show clearly a departure from the hitherto accepted T^3 law.

H. LONDON

537.312.62 : 537.533
3792. The self-absorption of beta-activated thallium in the superconducting state. O. RIEDEL AND F. SCHMEISSNER. *Z. Phys.*, **140**, No. 1, 92-6 (1955) In German.

Experiments on a thin thallium strip containing small amounts of the active isotope Tl^{204} show that the amount of β -radiation emitted does not change on passage to the superconducting state. It is concluded that there is no change in the arrangement of the magnetic fields inside the specimen, and that the contribution of the valency electrons to β -ray absorption also remains unchanged. E. P. WOHLFARTH

537.312.62 : 548.74
3793. Neutron diffraction observations on the superconducting state. M. K. WILKINSON, C. G. SHULL, L. D. ROBERTS AND S. BERNSTEIN. *Phys. Rev.*, **97**, No. 4, 889-91 (Feb. 15, 1955).

Neutron diffraction patterns for vanadium, lead and niobium have been obtained above and below their superconducting transition temperatures. No diffraction effects either of coherent or incoherent nature were found to result from the development of superconductivity. Accurate intensity measurements of the nuclear scattering reflections indicate little or no change in the Debye characteristic temperature of the lattice upon passage through the superconducting transition. A.

537.32
3794. On the thermo-electric power of metals. D. TER HAAR AND A. NEAVES. *Proc. Roy. Soc. A*, **228**, 568-74 (March 22, 1955).

Makinson's extension of Wilson's treatment of the second-order effects in metals is used to derive an expression for the contribution of the lattice current to the thermoelectric power of metals at those temperatures where electron-phonon scattering predominates. It is found that in this temperature region one may expect the thermoelectric effect to show a sign opposite to the one which follows from the simple electron theory of metals. This is because the term due to the departure from equilibrium of the lattice distribution is larger than the usual term and is of opposite sign. If the temperature is greatly

decreased or increased, the usual term predominates. The effect discussed may have a bearing on the behaviour of the thermoelectric power of the alkali metals, although it cannot explain this behaviour completely. A.

537.523

3795. Discontinuities in the thermoelectric properties of thin metallic films. J. SAVORNIN AND F. SAVORNIN. *C.R. Acad. Sci. [Paris]* **240**, No. 8, 850-2 (Feb. 21, 1955) In French.

Continuing previous work [Abstr. 5129 (1952)] the thermoelectric power of thin films of aluminium was studied. As the temperature of the hot junction was raised the film gave the same results as a thick sheet up to about 100°C, after which the thermoelectric power increased rapidly. On lowering the temperature and repeating the experiment, the temperature at which the abnormal increase set in usually became progressively higher. Though the experiments were conducted in air, there is reason to think the effect is not due to oxidation. Further work is in progress.

P. M. DAVIDSON

537.523

3796. Electromotive force and thermoelectric power of the aluminium-silver couple. A. ARON. *C.R. Acad. Sci. [Paris]* **240**, No. 8, 852-4 (Feb. 21, 1955) In French.

Results for vacuum-evaporated thick-layer thermocouples giving values of 5.5×10^{-6} V/deg C between 150 and 380°C. In exceptional cases after the initial heating there is an increase of thermoelectric power with temperature.

C. A. HOGARTH

ELECTRIC DISCHARGES 537.52

537.523.3

3797. The effect of varnish layers on the a.c. corona from wires and points. C. H. HERTZ. *Ark. Fys.*, **9**, Paper 2, 29-37 (1954) In German.

Describes oscillographic and photographic studies of corona from coated wires and points. The corona threshold voltage is reduced in the presence of a coating and, other things being equal, the corona currents are thereby increased.

J. D. CRAGGS

537.523.3

3798. Two different breakdowns between a positive electrode with small curvature and a plane. R. SIKSNA. *Ark. Fys.*, **9**, Paper 6, 77-82 (1954).

Experiments were carried out on positive corona between anodes of small radius (wire loops of various shapes) and a plane, in air at atmospheric pressure. Current-voltage characteristics were investigated in detail, with breakdown voltage-gap length data. These are presented and are discussed generally in terms of space charge distributions, etc.

537.523.3

3799. Some peculiarities of the current-potential characteristics of positive corona discharge. R. SIKSNA. *Ark. Fys.*, **9**, Paper 7, 83-91 (1954).

The characteristics of wire-cylinder coaxial corona

gaps were investigated. Currents were measured by determination of the discharge rate of a condenser connected in parallel with the discharge. Special attention was devoted to the so-called "noisy brush" régime. Detailed curves (e.g. of current-voltage) are given.

J. D. CRAGGS

537.523.3 : 621.3.015.5

3800. On the domain of electrical discharge classified by the influences of air flow and ultraviolet irradiation on the discharge characteristics in point-to-plane gaps in air. T. USHITA. *J. Inst. Elect. Engrs Japan*, **74**, No. 5, 564-70 (May, 1954) In Japanese.

It was found that the sparking potential can be raised to $2.5 \times$ the normal value as a result of air flow in the direction of the negative plane to the positive point in an airgap range where the streamer corona is developed before sparking and also where ultraviolet light has no effect on the discharge. With smaller airgaps, where the air flow has no effect, the sparking potential falls as a result of ultraviolet irradiation to some extent, whereas it rises in the intermediate range of gap length existing above these two regions. As a result, such electrical discharges can be grouped under three domains: Townsend, streamer and transition domains. As regards the mechanism of electrical discharge, it is concluded that corona threshold is influenced by the action in the ionization zone near the point and the suppression of the streamer corona can be explained as arising from lateral spread.

H. G. M. SPRATT (R)

537.523.3 : 621.3.015.532

3801. Some experiments on d.c. positive point-to-plane corona discharges. H. M. GAUNT AND J. D. CRAGGS. *Rep. Brit. Elect. Res. Assoc.*, Rep. L/T294, 11 pp. (1953).

An account is given of experiments in which the light pulses emitted by d.c. positive point-to-plane corona were observed using a photomultiplier, video amplifier and high writing-speed oscillograph. The pulses induced at the cathode are also described and compared with the light pulses. An attempt is made to relate the light pulse with the propagation of the discharge and to relate the induced pulse to the motion of the ions.

A.

537.523.3 : 621.3.015.532

3802. On the fluctuation of the initial corona voltage in air. M. HAYASHI AND Y. MIYOSHI. *J. Inst. Elect. Engrs Japan*, **74**, No. 5, 558-63 (May, 1954) In Japanese.

The mechanism of the fluctuation of point-to-plane initial corona voltage in air was investigated statistically, the effects of the various factors being observed with the application of linearly increasing voltages, both positive and negative. The factors studied were, variation of gas pressure and temperature, the presence of CO₂ and water vapour, the time interval between one check and the next, ion bombardment of the cathode by a glow discharge, the type of material forming the plane electrode, the effect of ultraviolet irradiation and the screening of light. It was concluded that the fluctuation was caused by the adsorption of gases by the cathode surface.

H. G. M. SPRATT (R)

537.523.5

3803. Effects of inert gases on d.c. arc discharge. B. L. VALLEE AND S. J. ADELSTEIN. Letter in *J. Opt. Soc. Amer.*, **45**, No. 1, 63 (Jan., 1955).

Discusses a recent publication by Stone [Abstr. 7275 (1954)] on the enhancement effects, etc., of the rare gases in spectroscopic analysis arc sources.

J. D. CRAGGS

537.525.3 : 537.525.72 : 537.525.8

3804. On photovariation of conductivity in non-self-maintained region of a low-frequency electric discharge. N. A. RAMAIAH, B. D. KHOSLA AND H. C. GAUR. Letter in *J. chem. Phys.*, **23**, No. 1, 212–13 (Jan., 1955).

Briefly describes the effect of external irradiation on the current-voltage characteristics of electrodeless a.c. discharges in iodine vapour (0.45 mm Hg pressure) immediately above the breakdown threshold. A short discussion is given.

J. D. CRAGGS

537.525.4

3805. Influence of the concentration of surface hydrogen on the threshold of microdischarges in vacuo. R. ARNAL. *C.R. Acad. Sci. [Paris]* **240**, No. 6, 610–12 (Feb. 7, 1955) In French.

Describes briefly observations of microdischarges, which precede vacuum sparks. They are considered to be due to a cascade process of emission of both positive and negative hydrogen ions from the electrodes. If the surface-adsorbed hydrogen diminishes, the frequency and amplitude of occurrence of the microdischarges diminish. Removal of hydrogen is brought about by the discharges themselves. Reabsorption leads to further discharges.

C. G. MORGAN

537.525.5 : 621.3.014.32 : 621.373.3

3806. Relaxation oscillations and noise from low-current arc discharges. M. I. SKOLNIK AND H. R. PUCKETT, JR. *J. appl. Phys.*, **26**, No. 1, 74–9 (Jan., 1955).

Under certain conditions the usual gas-discharge circuit was found to give rise to relaxation oscillations. The relaxation oscillations produce a series of very narrow pulses with random pulse repetition interval, which appear as noise. The amount of noise was found to depend upon the gas, the cathode electrode material, the power supply voltage and the external circuit configuration. It seems that this mechanism may be responsible for most of the high-level noise usually reported from gas discharges. The pulsed nature of the apparently continuous discharge appears to be a fundamental property of the low-current, cold-cathode arc which has not been considered previously.

A.

537.525.72

3807. The growth of electrodeless discharges in hydrogen. G. FRANCIS. *Proc. Phys. Soc. [London]* **B**, **68**, Pt 3, 137–47 (March, 1955).

Measurements have been made on the starting potential, current and rate of growth of current of electrodeless discharges in hydrogen. The gas was contained in cylindrical glass or quartz vessels placed between plane parallel electrodes. The wavelength was varied from 50 m to 6×10^6 m (frequency range 6 Mc/s to 50 c/s), and the gas pressure from 1 to 76 mm Hg. At short wavelengths the starting potential

and current are low, and the discharge develops slowly. At a critical "cut off" wavelength the starting potential rises abruptly and then remains almost constant to the longest wavelengths. At wavelengths just greater than cut-off the current is large, grows rapidly and flows continuously: at all longer wavelengths a smaller current flows in a brief pulse which occurs near each peak of the applied field, and is of constant height and shape. The growth of the pulses is thought to be due to ionization in the gas, and electron emission from the walls of the vessel by photons. A pulse ceases when wall and space charges sufficiently reduce the field in the gas. Pulses occur so regularly that electrons must be left over from one pulse to enable the next to start. They are loosely bound on the "anode" wall at the end of one pulse and easily pulled off when the field reverses. This emission occurs in quite small fields ($< 1000 \text{ V cm}^{-1}$), and is distinct from normal field emission. This idea has been tested using alternating square-wave fields of very long period, and by removing the wall charges.

A.

537.525.8

3808. On the thin [surface] layers formed in self-maintained high vacuum discharges in methane. R. HAEFER. *Acta phys. Austriaca*, **9**, No. 1, 1–17 (1954) In German.

The degree of vacuum used was $\sim 10^{-3}$ to 10^{-4} mm Hg. Deposition effects and the nature of the deposited layers were studied in a co-axial cylinder discharge tube, in an axial magnetic field. The discharge characteristics are discussed in detail. Electron microscope photographs of the fine particles, composing the deposited layers, are given.

J. D. CRAGGS

537.525.8

3809. Space-charge effects in high-frequency discharges. II. M. CHENOT. *J. Phys. Radium*, **16**, No. 2, 101–7 (Feb., 1955) In French.

For Pt I, see Abstr. 2778 (1955). Describes further work on the characteristics of discharges excited at low pressures with electrodes external to the tube. Frequencies of operation were ~ 46 Mc/s. Internal electrodes, passing a maintained current, are immersed in the discharge and the collector characteristics of these internal electrodes are discussed.

J. D. CRAGGS

537.525.8

3810. Construction of the positive column of a glow discharge at high pressure. R. G. FOWLER. *Proc. Phys. Soc. [London]* **B**, **68**, Pt 3, 130–6 (March, 1955).

It is proposed that the construction of the positive column into a wall-independent filament which sets in with increasing density comes about as a consequence of concentrational effects accompanying electron energy loss. As a first approximation this energy loss has been treated as a damping field acting on the electron motions only. In helium, using either Maxwell-Boltzmann or Smit distributions, the constriction is predicted to lie in a range of densities in which it is indeed known to occur. A semi-empirical calculation of the critical values is made for other gases as well, with reasonable agreement with the limited data available.

A.

537.529

3811. The physics of electrical breakdown in solid insulation. R. ROMPE. *S.B. Dtsch. Akad. Wiss. Berlin, Kl. tech. Wiss.*, **1954**, No. 1, 14 pp. In German.

Reviews current theories of thermal and intrinsic breakdown and recent investigations with photoconducting CdS single crystals [Böer *et al.*, Abstr. 876, 766 (1953) and 11050 (1954)], which indicate that thermal breakdown always occurs in these crystals. The nature of the current-voltage characteristics and the origin of electroluminescence at currents approaching the breakdown value, are discussed. J. H. MASON

X-RAYS 537.531

537.531

3812. A note on the X-ray spectrum of a 70 MeV synchrotron. L. E. H. TRAINOR AND S. B. BROWN. Note in *Canad. J. Phys.*, **33**, No. 2, 110–12 (Feb., 1955).

Evidence of a systematic error in spectrum measurements made by McDiarmid [Abstr. 6827 (1953)] is pointed out. Correction of this error may suffice to bring the measurements into agreement with theory.

J. J. WILKINS

537.531 : 535.33.07

3813. High luminosity spectrometry in the soft X-ray region. I. The cylinder spectrometer. C. B. VAN DEN BERG AND H. BRINKMAN. *Physica*, **21**, No. 2, 85–102 (Feb., 1955).

A new kind of focusing X-ray spectrometer is described in which the crystal is bent in the shape of a cylinder and the spectra are observed along the cylinder axis. This instrument shows a high luminosity and a high resolving power. The line-shaped X-ray source is efficiently used; the spectral lines are stigmatic images of the line focus. The wavelength dispersion is nearly constant. The characteristics of the spectrometer are calculated. A spectrometer with a cylindrical mica crystal with radius of curvature 200 mm and reflecting surface of $14 \times 4 \text{ cm}^2$ was built and proved to be very reliable. The intensity gain over known X-ray spectrometers is calculated and proved to be as large as 60 to 90, for large glancing angles ϕ , not accounting for the fact that a much larger wavelength region (about 500 XU) can be covered in one exposure. Wavelength dispersion 16 XU/mm. The adjustment is done optically. The spectrometer for wavelengths from 9 to $19 \text{ \AA}$ is enclosed in a steel tank that can be evacuated. A typical spectrum is shown. The instrument can also be used as a stigmatic point-focusing monochromator. A.

537.531 : 535.343 : 548.7

3814. X-ray spectroscopy of valence and conduction bands of potassium chloride. L. G. PARRATT AND E. L. JOSSEM. *Physica*, **20**, No. 11, 1134–7 (Nov., 1954).

A discussion of impurity states, energy gaps and density of states in crystalline KCl as revealed by an emission and absorption study of the K-spectra.

A. E. DE BARR

537.531.08 : 537.533.9

3815. Connection between dose measurement for fast electrons (3 to 15 MeV) and X-rays. G. BREITLING

AND R. GLOCKER. Note in *Naturwissenschaften*, **42**, No. 1, 11–12 (1955) In German.

An apparent discrepancy between the sensitivity of an air-equivalent scintillation counter (75% anthracene, 25% chloranthracene) and an air-wall ionization chamber for fast electrons and X-rays of such energy that only Compton electrons are involved, is put down to a difference in the utilization of secondary electrons in the two instruments. This explanation is supported by calculations based on energy distribution curves for secondary electrons.

J. THEWLIS

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533.3

3816. Wave-mechanical theory of electron-optical imaging. I. W. GLASER AND G. BRAUN. *Acta phys. Austriaca*, **9**, No. 1, 41–74 (1954) In German.

A method is given, in direct analogy with wave optics, for determining the Schrödinger wave-function in any image plane from its value in a given (object) plane with the aid of Green's theorem; it corresponds to a generalization of Kirchhoff's treatment of diffraction. As the required Green's function cannot be rigorously derived, it is obtained as a series in powers of $\hbar$, asymptotic for $\hbar \rightarrow 0$, by a method akin to the WKB method in wave mechanics. The method of stationary phase is used to evaluate the resulting diffraction integrals. The meaning of the points of stationary phase in terms of geometrical optics is indicated, the number of solutions is discussed and the relationship with geometrical electron optics and wave mechanics demonstrated. The laws of the former follow from those of the latter when the de Broglie wavelength is vanishingly small ($\hbar \rightarrow 0$). The physical significance of the method of stationary phase is discussed. The results will be used in a later paper for a complete wave-mechanical treatment of paraxial focusing in electromagnetic fields of rotational symmetry.

V. E. COSSLETT

537.533.3 : 535.41

3817. Fresnel interference with a biprism for electrons. G. MÖLLENSTEDT AND H. DÜKER. Letter in *Naturwissenschaften*, **42**, No. 2, 41 (1955) In German.

In exact analogy with the optical biprism experiment, an electrical field is formed around a metallized quartz fibre such that two coherent beams of electrons are produced from a single incident beam. The interference fringes formed on a screen (or photographic plate) have a spacing of $1600 \text{ \AA}$, in agreement with that calculated from geometry and the wavelength of the electron illumination. The quartz fibre is 3μ in diameter and is held 10 V positive to two parallel grounded electrodes symmetrically disposed at a distance of 2 mm. The system forms a simply controllable electron interferometer. V. E. COSSLETT

537.533.331

3818. Two new simplified systems for the correction of spherical aberration in electron lenses. G. D. ARCHARD. *Proc. Phys. Soc. [London] B*, **68**, Pt 3, 156–64 (March, 1955).

Two new simplified electrostatic systems for the

correction of third-order spherical aberration in electron lenses are described and related to earlier systems of Seeliger and Burfoot. Numerical examples are given in which the voltages and positioning tolerances of the various electrodes are calculated. The effects of scaling and change of electrode shape are discussed.

A.

537.533.35

3819. The deformation of electron diffraction rings by lens aberrations. H. GRÜMM AND J. WAGNER. *Acta phys. Austriaca*, **9**, No. 1, 33-40 (1954) In German.

The influence of lens errors on electron diffraction ring patterns has been investigated experimentally in a Siemens electron microscope. The main deformation is oval in form, and is ascribed to astigmatism arising from residual imperfections in the pole pieces. The extent of the deformation is calculated on a first-order theory; a short discussion of third-order effects shows them to be very small. Observation of diffraction rings could be used as a test for the residual astigmatism of electron lenses.

V. E. COSSLETT

537.533.35

3820. Modified viewing chamber windows for electron microscopes. G. C. CLAVER, JR. Letter in *J. Opt. Soc. Amer.*, **45**, No. 2, 132 (Feb., 1955).

A modification to the viewing winding of R.C.A. electron microscopes, series 2, eliminates the possibility of the rubber gasket which seals the window being forced out of position by the external air pressure.

M. E. HAINE

537.533.35 : 621.385.833

3821. A reflexion electron microscope. V. E. COSSLETT AND D. JONES. *J. sci. Instrum.*, **32**, No. 3, 86-91 (March, 1955).

The design, construction and performance are described of an apparatus specially built for microscopy of solid surfaces which are illuminated by an electron beam at grazing incidence. General requirements of design are discussed as well as practical details. Special features are: a continuously variable tilt of the illuminating system from 0 to 10°; an object stage possessing several degrees of freedom; and an objective lens of long working distance which allows specimens to be examined of a size usual in metallurgy, and permits them to be subjected to heat or other treatment, since they are outside the lens pole piece. The magnification is continuously variable from $\times 500$ to $\times 10,000$. Electron diffraction patterns can also be obtained without changing the position of the specimen; the lens system is designed so as to minimize the distortion, rotation and chromatic errors in diffraction patterns. Typical micrographs are shown of both ferrous and non-ferrous metals, and difficulties in the interpretation of reflection pictures are briefly discussed.

A.

537.533.74

3822. On the meaning of the "discrete energy loss" of medium fast electrons in solids. H. FRIEDMANN. Note in *Naturwissenschaften*, **41**, No. 24, 569-70 (1954) In German.

Experimental results for small angles ($\theta = 0.5 \times 10^{-3}$) and energies 0-50 eV are presented. A marked

rise at 20 eV is interpreted as excitation of electrons in low-lying bands.

G. E. BROWN

537.533.74

3823. The Coulomb scattering of high-energy electrons and positrons by nuclei. R. M. CURR. *Proc. Phys. Soc. [London] A*, **68**, Pt 3, 156-64 (March, 1955).

The Mott cross-section for the Coulomb scattering of high-energy electrons and positrons by atomic nuclei has been expressed by McKinley and Feshbach (1948) in terms of series in powers of $Z/137$, up to terms in Z^4 , where Z is the atomic number of the scattering nucleus. The coefficients of these series, which were evaluated numerically, have been recalculated and some minor errors corrected. Further coefficients have been calculated to enable application of the method to heavy elements and the resulting cross-section, expressed as a ratio to the Rutherford cross-section, is given in the form of a single power series.

A.

537.533.79

3824. Experimental investigations on electron interaction. E. A. ASH AND D. GABOR. *Proc. Roy. Soc. A*, **228**, 477-90 (March 22, 1955).

Certain observations in low-pressure gas discharges in magnetrons appear to indicate an electron interaction effect several orders of magnitude in excess of the theoretical values based on binary encounters only. As the Coulomb interaction in low-pressure plasmas and in electron clouds usually extends over a range which contains at least several thousand electrons, it was not clear whether these observations indicated a breakdown of the theory, or some new effects, other than electron interaction. New experiments were therefore designed to establish an upper limit for the magnitude of the electron interaction effect. Both plasmas in thermal equilibrium and pure electronic space charges were investigated. The basic experimental method in each case was shooting a very carefully collimated electron beam through the charge cloud, and measuring the scattering by direct observation on a fluorescent screen. The apparatus was designed to resolve angles down to 10^{-4} . The density of the equilibrium plasma was inferred from capacity measurements on a thin wire probe in the plasma. The density of the electron cloud was determined by measuring the electron-optical effects produced. It is concluded that both for the plasma as for the electron cloud the scattering is less than five times the value predicted by the theories neglecting simultaneous multiple collisions. The interaction is therefore so small that it cannot be expected to account for the observed anomalies either in low-pressure gas discharges or in other electronic devices.

A.

537.533.8

3825. The statistics of electron avalanches. W. LEGLER. *Z. Phys.*, **140**, No. 2, 221-40 (1955) In German.

A theoretical treatment of avalanche growth. Various processes, which lead to secondary electron production, are treated. Formative times are derived in terms of the discharge constants, together with estimates of the success of an avalanche's leading to breakdown as the critical condition $\gamma(e^{ad} - 1)$ is approached.

J. D. CRAGGS

537.533.8

3826. On the escape mechanism of secondary electrons from insulators. A. J. DEKKER. *Physica*, **21**, No. 1, 29–38 (Jan., 1955).

Starting from the Boltzmann transport equation, the influence of lattice vibrations, traps and donor levels on the secondary yield of insulators is investigated by making a number of simplifying assumptions. For high trap densities it is found that the yield for high primary energies should be inversely proportional to the square root of the trap density. The slowing-down of secondaries as a result of the interaction with lattice vibration leads to a temperature effect which for MgO is in agreement with the observations. Within the approximations made, the energy distribution of the emitted secondaries turns out to be independent of temperature and seems to be rather insensitive to the initial energy distribution of the secondaries as produced by the primary beam. A.

537.533.8

3827. The effect of finite nuclear size on bremsstrahlung production. S. J. BIEL AND E. H. S. BURHOP. *Proc. Phys. Soc. [London] A*, **68**, Pt 3, 165–72 (March, 1955).

Calculations have been made of the bremsstrahlung spectrum emitted in different directions following electron-nuclear collisions, allowing for the finite distribution of the nuclear charge. Calculations were carried out for charge distributions of the uniform sphere, spherical shell, Gaussian and exponential forms, as well as for a uniform spherical core with a distribution falling off exponentially at the surface. In each case the parameters of the distribution were chosen to agree with the elastic electron scattering data at 16 MeV. The modification of the angular distribution obtained from the Bethe-Heitler formula for a point nucleus is large for electron energies above 20 MeV. A.

537.533.9

3828. Probing of barrier layers with an electron beam. W. EHRENBURG AND CHI SHI LANG. *Physica*, **20**, No. 11, 1137–8 (Nov., 1954).

A study is made of the "electron voltaic" effect, i.e. the e.m.f. developed by a photoelement under electron bombardment. It is concluded that the apparent depth of barrier corresponding to the electron energy for which the gain is a maximum represents a diffusion range rather than a barrier thickness, or alternatively that the barrier begins only at an appreciable depth behind the surface. J. THEWLIS

537.533.9 : 523.72

Nonlinear theory of space-charge wave in moving, interacting electron beams. See Abstr. 3400

537.534.3

3829. High-order focusing by a uniform magnetic field with straight-line boundaries. E. T. S. WALTON. *Proc. Roy. Irish Acad.*, **57A**, No. 1, 1–13 (Nov., 1954).

A special drawing instrument has been constructed with which to study the focusing of rays of charged particles by a uniform magnetic field extending over a limited area. This instrument will draw the ideal exit boundary of the field corresponding to any arbitrary entrance boundary. It has been used to

determine what straight line boundaries will give the best focusing of rays diverging over as wide an angle as possible. The results have been given in graphs suitable for use in the design of sector-shaped magnetic analysers which combine large aperture with good focusing. It has been shown that these designs also give convenient and high-order focusing of particles of nearby magnetic rigidity. A.

537.534.74

3830. Cross-sections for elastic proton-proton and neutron-proton collisions. L. BERETTA, C. VILLI AND F. FERRARI. *Nuovo Cimento Suppl.*, **12**, No. 3, 499–548 (1954) In Italian.

A synthesis of all the experimental data on these cross-sections is presented in both tabular and graphical form. Both the differential and total cross-sections are given. The bibliography comprises 56 references for proton-proton, and 78 for neutron-proton collisions. J. HUGHES

537.534.74

3831. Direction of polarization of proton spin produced by elastic scattering. L. MARSHALL AND J. MARSHALL. Letter in *Nature [London]* **174**, 1184–5 (Dec. 25, 1954).

Elastic scattering of protons on helium, in the 1–15 MeV region, goes through an inverted doublet in the *P* state. This provides, in principle, a method of determining the direction of any polarization of the beam produced in a previous scatter. A 435 MeV, 60% polarized, beam of protons was produced by elastic scattering on beryllium. After slowing down by copper absorber, the direction of polarization was observed by the above means. Tentative conclusions are in agreement with the assumption that the polarization is produced by the spin-orbit interaction postulated in the nuclear shell model. P. T. MATTHEWS

537.534.74 : 539.185

3832. Theory of polarization of nucleons scattered elastically by nuclei. S. FERNBACH, W. HECKROTTE AND J. V. LEPORE. *Phys. Rev.*, **97**, No. 4, 1059–70 (Feb. 15, 1955).

A study of the nucleon polarization to be expected when nucleons are elastically scattered from nuclei is presented. The polarization effect is a consequence of the fact that the nucleon-nucleus interaction may be represented as a complex spin-dependent potential. The existence of such a potential is suggested by the nuclear shell model and the spin-dependence of the nucleon-nucleon interaction. Qualitative arguments are advanced to determine this potential in terms of the nucleon-nucleon interaction. Although the polarization effect is by no means confined to elastic scattering, it is in this case particularly useful, since the large diffraction cross-sections observed experimentally ensure relatively high yields of polarized particles. A number of theoretical studies have been carried out, for both neutron and proton scattering, which show that almost full polarization can occur. The calculations have been carried out by using the W.K.B. approximation as usually applied to the nuclear optical model. The method has been checked by carrying out an exact phase shift analysis for a particular case. The results show that studies of nucleon polarization can illuminate some aspects of

nuclear structure, since the polarization depends on the particular nucleus used as a target as well as upon the form of the interaction. A.

537.534.75 : 539.164.75

3833. Stopping power of water films. R. H. ELLIS, JR., H. H. ROSSI AND G. FAILLA. *Phys. Rev.*, **97**, No. 4, 1043-7 (Feb. 15, 1955).

By a method which has been previously used with polystyrene and acetylene, the stopping powers of water films and water vapour for low-energy α -particles have been compared. There appears to be no anomaly, the mass stopping powers being equal to within a precision of about 5%. A.

DISCHARGE TUBES . COUNTERS 537.54

537.542

3834. Bromine-quenched and iodine-quenched Geiger-Müller counters. G. BROGREN. *Ark. Fys.*, **9**, Paper 9, 101-5 (1954).

Describes experiments on self quenching in halogen/rare-gas counters. Reference is made to complex-vapour/rare-gas counters in connection with the necessary conditions for self quenching. The latter are (i) the ionization potential of the vapour (or halogen) must be < that of the rare gas and (ii) the vapour must give continuous absorption of radiation of a certain energy range. The behaviour of halogen/rare-gas counters is described in detail, with reference to experimental data. J. D. CRAGGS

537.542

3835. The thermionic component of the background count in Geiger counters. R. MEUNIER, M. BONPAS AND J. P. LEGRAND. *J. Phys. Radium*, **16**, No. 2, 145-8 (Feb., 1955) In French.

Describes experiments with a variety of vapour fillings and cathode materials on the variation of background count with temperature, up to nearly 450°K. Effective cathode work-functions appear to be about 0.6 eV. The effect is attributed to the emission of alkali positive ions, present as contamination.

J. D. CRAGGS

537.542

3836. Geiger counters with "internal counting" containing tritium-water vapour. R. MEUNIER, M. BONPAS AND J. P. LEGRAND. *J. Phys. Radium*, **16**, No. 2, 148-51 (Feb., 1955) In French.

Describes a sensitive Geiger counter technique for the estimation of tritium concentrations. The tritium, in the form of water vapour, is introduced with a suitable self-quenching gas mixture into the counter. For a 20 cm³ counter, tritium concentrations of 1 in 10¹⁴ constitute the sensitivity limit.

J. D. CRAGGS

537.542 : 537.533.75

3837. Measurements of the energy loss distribution for minimum ionizing electrons in a proportional counter. D. WEST. Letter in *Proc. Phys. Soc. [London] A*, **66**, Pt 3, 306-8 (March, 1953).

This was investigated for the gases krypton, argon and neon and the results are tabulated.

537.542 : 539.185.08

Detection of thermal neutrons by borazole-filled proportional counters. See Abstr. 4105

537.542

3838. Geiger counters. R. R. FOY. *Rev. Mexicana Fis.*, **2**, No. 4, 215-21 (Oct., 1953) In Spanish.

The cathodes of the counters are made by evaporating part of the wire on to the glass envelope. This method of construction increases the time stability of the counter, probably due to improved outgassing. The effects of temperature, and of connecting a resistance and a condenser in parallel between the cylinder and earth were studied. J. HUGHES

537.542

3839. A new material and techniques for the fabrication and measurement of very thin films for use in 4 π -counting. B. D. PATE AND L. YAFFE. *Canad. J. Chem.*, **33**, No. 1, 15-23 (Jan., 1955).

A new method for preparing thin films for use in β -spectrometry and 4 π -counting is described. These films, made of polyvinylchloride-acetate copolymer are readily prepared with superficial densities as low as 1 μ g per cm². The films have good tensile strength and show excellent resistance to acids, alkalies and many organic reagents. Their thickness may be determined (a) gravimetrically, (b) radiometrically and (c) optically either by transmission or reflection. They can be made conducting by distilling a thin gold layer on to them. The thickness of the gold layer can be determined spectrophotometrically. A.

537.542 : 539.185.08

3840. Fission chambers for neutron detection. R. AVES, D. BARNES AND R. B. MACKENZIE. *J. nuclear Energy*, **1**, No. 2, 110-16 (Dec., 1954).

Describes mechanical features. See also abstract following.

537.542 : 539.185.08

3841. Electrical characteristics of fission chambers. J. E. R. HOLMES, D. D. MCVICAR, L. R. SHEPHERD AND R. D. SMITH. *J. nuclear Energy*, **1**, No. 2, 117-23 (Dec., 1954).

See preceding abstract. Operating characteristics are here described.

537.542

3842. Plate-separation requirements for standard free-air ionization chambers. F. H. ATTIX AND L. DELAVERGNE. *J. Res. Nat. Bur. Stand.*, **53**, No. 6, 393-402 (Dec., 1954).

A method is described for measuring ionization losses resulting from inadequate separation of the parallel plates in free-air chambers. The ionization produced by X-rays scattered out of the collimated beam was measured separately and subtracted from the total to obtain the ionization contribution of only the electrons from the beam. Losses of this electron ionization are tabulated for plate separations from 6 to 36 cm, with moderately and heavily filtered X-rays from 50 to 250 kV constant tube potential. Results are also converted into cylindrical co-ordinate form for application to chambers other than the parallel-plate type. A method is suggested for measurement, in other free-air chambers, of the

contribution of ionization by scattered X-rays. Ionization-loss results are compared with previous experiments. A.

537.542

3843. Some lithium iodide phosphors for slow neutron detection. K. P. NICHOLSON AND G. F. SNELLING. *Brit. J. appl. Phys.*, **6**, No. 3, 104-6 (March, 1955).

An account is given of the growing of single crystals of lithium iodide for use as scintillation detectors of slow and resonance energy neutrons. Tin, europium and samarium activators have been tested and their relative merits are presented. Where possible the phosphor properties are compared with a standard sodium iodide crystal. The practical application of lithium iodide crystals to neutron counting and the limitations imposed by their sensitivity to γ -radiation are discussed. A.

537.542

3844. Remarks on the spark counter. S. ROSENBLUM. Letter in *J. Phys. Radium*, **16**, No. 2, 159 (Feb., 1955) In French.

537.542

3845. A detector system with circular symmetry for the automatic control of a Wilson chamber. H. DE LABOULAYE AND P. BARREAU. *J. Phys. Radium*, **16**, No. 2, 151-4 (Feb., 1955) In French.

Describes a development of the counter-controlled cloud chamber in which a circular wire, mounted in the chamber, is used to provide a tripping pulse, derived from charge picked up from the track ionization. In this way, the angular distribution of tracks from a central source may be measured, in the plane of the wire. Calibration checks are described, using α -tracks from a uranium source. J. D. CRAGGS

537.542

3846. On the use of absorbing screens within the sensitive volume of a diffusion cloud chamber. A. ROGOZINSKI. Letter in *J. Phys. Radium*, **16**, No. 2, 166-7 (Feb., 1955) In French.

Provides a simple method of placing lead screens within a diffusion cloud chamber without interrupting the satisfactory operation of the chamber.

A. J. EGGINTON

537.542 : 537.591

3847. The magnetic cloud chamber equipment for the momentum measurement of the cosmic ray particles. S. FUKUI, T. KITAMURA AND S. OZAKI. *J. Inst. Polytech. Osaka City Univ. B*, **5**, No. 6, 11-23 (Oct., 1954).

The chamber, of a cylindrical type, was employed for the measurement of the momentum spectrum of the cosmic-ray μ -mesons at sea level. In this paper the following subjects are described: a device for the small dead space of the chamber; the action of the series of slow expansions following each fast expansion in order to make the background of the chamber small; an electronic control for constant temperature; the current of the sweeping field as the indicator of the condition of the chamber; the use of least-square method for the determination of the track curvature. A.

537.542 : 621.318.3 : 621.318.423

3848. Magnetic field coils for a Wilson cloud chamber. G. WIND AND M. SCHÉRE. *J. Phys. Radium*, **16**, No. 2, 92-6 (Feb., 1955).

Discusses the design of air-cored coils to provide a uniform field throughout a useful volume of $60 \times 40 \times 12$ cm. A design is discussed using Al cable (cross-section 3.35 cm^2), carrying 500 A, wound on rectangular formers, the winding area being rectangular in cross-section. The field distribution is then calculated in detail, and the shape of the winding cross-section modified to reduce the inhomogeneity. The coils are oil-immersed, the oil being water-cooled. A field of 1950 Oe was achieved with a power input of 53 kW. The variation of the axial component of the field over the required volume did not exceed 1%.

E. A. ASH

537.543

3849. Electron velocity in the cavity cathode. V. VEITH. Note in *Naturwissenschaften*, **42**, No. 2, 40-1 (1955) In German.

A special electron valve is constructed to test the high current emission from cavities, which has been recently discussed [e.g. Abstr. 8475 (1953)]. A cylindrical cathode emits from the outside on one side and through slits, from the inside, on the other. By means of an accelerating grid and a.c. voltages on a collector it is shown that the electron velocity is higher for electrons emitted from the inside. It is suggested that initial velocities in the slit opening explain the deviations from the Child-Langmuir law. H. MOTZ

IONIZATION . THERMIONICS 537.56/.58

537.56

3850. Theory of ionization fluctuations. J. E. MOYAL. *Phil. Mag.*, **46**, 263-80 (March, 1955).

The distributions of the loss of energy by ionization of a fast primary and of the numbers of ion pairs it produces are derived. It is shown that down to quite small values of the primary ionization, both can be represented by the same "universal" distribution if the variables are reduced by a proper choice of scale and origin, which accounts for the experimental fact that ion pair numbers are proportional to primary energy loss. These conclusions remain valid when one takes into account quantum resonance effects and the details of atomic structure of the absorber. A.

537.564

3851. Ionization energies of atoms and atomic ions. W. FINKELNBURG AND W. HUMBACH. *Naturwissenschaften*, **42**, No. 2, 35-7 (1955) In German.

A comprehensive table of experimental values and values extrapolated by several methods is given.

G. E. BROWN

537.564 : 537.533.9

3852. Specific ionization by high-energy electrons. W. C. BARBER. *Phys. Rev.*, **97**, No. 4, 1071-7 (Feb. 15, 1955).

The average specific ionization produced by elec-

trons of energies ranging from 1 to 34 MeV was measured in H_2 , He and N_2 at atmospheric pressure. The measurements were made by sending a collimated beam of electrons through an ionization chamber into a Faraday cup. At minimum ionization the number of ion pairs per cm (probable specific ionization) was (7.56 ± 0.09) , (6.15 ± 0.08) and (53.2 ± 0.7) at N.T.P. in the three gases, respectively. If these results are compared with the theory of energy loss, the values of W (the average number of electron volts to produce an ion pair) are calculated to be (37.8 ± 0.7) , (44.5 ± 0.9) and $(34.8^{+0.9}_{-0.7})$ for the respective gases. The corresponding minimum values of the total specific ionization are calculated to be (9.19 ± 0.18) , (7.55 ± 0.16) and $(61.6^{+1.2}_{-1.3})$ ion pairs per cm. The relativistic increase in ionization from minimum to 34 MeV agrees with the calculated increase in energy loss to within 1% for N_2 , but in He and H_2 the increase in ionization is less than the predicted increase in energy loss. The effect is more certain in H_2 where an increase of about $3.3 \pm 0.7\%$ in W is observed. Calculations indicate that this effect may be due to the production of Cherenkov radiation which fails to produce ions in the gas. A.

537.564 : 539.164.75

3853. Ionization and alpha-particle energy loss in different gases. W. RIEZLER AND A. RUDLOFF. *Ann. Phys. [Leipzig]* **15**, No. 3-4, 224-45 (1955) In German.

A series of measurements of Bragg waves in a wide variety of gases is described which permits the specific ionization and energy loss to be determined. Experimental details and theory of the method are described.

C. G. MORGAN

537.568

3854. The detachment of electrons from negative hydrogen ions by impact with neutral atoms. D. W. SIDA. *Proc. Phys. Soc. [London]* **A**, **68**, Pt 3, 240-3 (March, 1955).

Born's approximation is applied to calculate the cross-section for detachment of an electron from a negative ion of hydrogen in collision with a helium atom as a function of the energy of the ion. The results are compared with observed data and show agreement to within a factor of two or so over an energy range from 100 to 20 000 eV. A.

537.583

3855. Reduction of alkaline earth oxides by methane. J. C. S. WAGENER. Letter in *J. chem. Phys.*, **23**, No. 1, 204 (Jan., 1955).

Contradictory results obtained on oxide cathodes activated by processing in methane are explained by a calculation of the equilibrium pressure of CO above the hot oxides. These pressures are very low, even at 1475°K the value is only 8×10^{-2} mm Hg. Since at this pressure 10 cm^3 methane would only react to produce $1 \mu\text{g}$ Ba, continuous flow or repeated refilling is required to obtain thorough activation.

A. H. W. BECK

537.583 : 621.385.032.216

3856. Evaporation of barium and strontium from oxide-coated cathodes. L. A. WOOTEN, A. E. RUEHLE

AND G. E. MOORE. *J. appl. Phys.*, **26**, No. 1, 44-51 (Jan., 1955).

Rates of evaporation of Ba and Sr from oxide cathodes in a practical tube structure were measured during life tests up to 20 000 hours. The effects on evaporation rates are shown for (a) impurity in the Ni support, (b) cathode temperature, and (c) space current. It is concluded that: (1) The product evaporating from commercial type cathodes under normal conditions is largely Ba metal; <5% is Sr; <2% is BaO; and <0.01% is SrO. (2) Chemical reducing agents in the support metal are important in determining the rate of Ba evaporating during life. (3) A factor not closely controlled in the present experiments—anode and grid composition—affects the rate markedly. This is especially true for the evolution of Ba during exhaust. (4) Within the precision of these experiments, there is (a) no correlation between the rate of Ba evaporation and thermionic activity of individual cathodes, and (b) no effect of space current on the rate of Ba evaporation. A.

COSMIC RAYS 537.591

537.591.1

3857. Estimates of the angle of scattering, increase in intensity at high latitudes and relative abundances of slow secondary nucleons in the atmosphere. TSAI-CHÜ AND M. MORAND. *C.R. Acad. Sci. [Paris]* **240**, No. 5, 513-15 (Jan. 31, 1955) In French.

Observations of slow nucleons in cosmic rays provide a value for the mean angle of scattering by collision between primary and secondary nucleons of about 4.4° . The increase in intensity of the secondary nucleon component is shown to be as much as 6.5% at latitudes greater than $46^\circ 10'$ and is proportional to the primary energy.

A. J. EGGINTON

537.591.1

3858. Study of charged heavy unstable cosmic ray particles. P. R. BARKER, D. M. BINNIE, B. D. HYAMS AND R. J. ROUT. *Phil. Mag.*, **46**, 300-6 (March, 1955).

A technique for the direct counter detection of heavy unstable cosmic-ray particles stopping in a cloud chamber is described. It is shown that the method is about three times more efficient than methods previously used when detecting particles with lifetimes greater than 5×10^{-9} sec. The observation of eight, well-identified, unstable particles is reported; they all have properties consistent with the K_μ -particle. A.

537.591.1

3859. High-altitude cosmic-ray neutron density at the geomagnetic pole. H. A. C. NEUBURG, R. K. SOBERMAN, M. J. SWETNICK AND S. A. KORFF. *Phys. Rev.*, **97**, No. 5, 1276-9 (March 1, 1955).

Two successful balloon flights were launched near the geomagnetic North Pole, bearing low-energy cosmic-ray neutron detectors. The neutron maximum was found to occur at 75 ± 5 mb. A value of 161 mb was found for the mean absorption depth, L . A.

537.591.1

3860. Measurement of multiply charged cosmic rays by a new technique. J. LINSLEY. *Phys. Rev.*, **97**, No. 5, 1292–302 (March 1, 1955).

The Cherenkov effect has been applied to the problem of determining the charge of cosmic rays. Cloud chamber photographs have been obtained of the events that caused large signals from a thin Cherenkov counter during a balloon flight which carried the apparatus above most of the atmosphere. They show that the Cherenkov counter was notably effective at discriminating against the background effects that plague counter measurements on the charge spectrum of cosmic rays, for a relatively large proportion of the signals were caused by single heavily ionizing particles. The theory of the Cherenkov effect associates a lower velocity limit with the signal amplitude requirement that those particles met. Their ionization was determined well enough to classify particles of such velocity as having $Z = 2$ or $Z > 2$ with considerable certainty. The vertical flux of doubly charged particles with kinetic energy $> (610 \pm 100)$ MeV/nucleon beneath 17 g/cm² of atmosphere and 13 g/cm² of local matter is found to be $(79 \pm 11)/\text{m}^2 \cdot \text{sec. steradian}$. That result and currently accepted assumptions concerning absorption imply the value $(135 \pm 20)/\text{m}^2 \cdot \text{sec. steradian}$ for the extrapolated vertical flux of primary α -particles with energy above (670 ± 100) MeV/nucleon. Some of the α -particles were seen to interact in copper plates within the cloud chamber. The observations indicate that the collision mean free path is (100 ± 25) g/cm². The problem of counter measurements on components heavier than helium is scrutinized. A.

537.591.1 : 523.165

3861. The acquirement of cosmic ray energies by electromagnetic induction in galaxies. W. F. G. SWANN. Letter in *Phys. Rev.*, **96**, No. 1, 240 (Oct. 1, 1954). *J. Franklin Inst.*, **258**, No. 5, 383–93 (Nov., 1954).

A generalization and discussion of the principle formerly applied by the writer to a special problem [see *Phys. Rev.*, **43**, 217–20 (Feb. 15, 1933). Simplified version, *J. Franklin Inst.*, **258**, No. 3, 205–12 (Sept., 1954)]. Attention is confined to problems where the magnetic field grows with time with axial symmetry, that is to problems in which the electric and magnetic fields, E and H , show no variations with the θ co-ordinate. It is shown that: (1) If a charged particle starts to acquire kinetic energy at $t = 0$, and if the magnetic field is zero at $t = 0$, then the particle acquires energy continually. (2) If, at $t = 0$, the magnetic field is finite, a sufficient, but by no means necessary, condition for continual gain of energy is that $|E| \geq |H|$ for all positions and times. (3) If, at $t = 0$, both magnetic field and particle energy are finite, then, depending upon the sign of the initial angular velocity, the particle may gain or lose energy initially. However, if $|E| \geq |H|$, it will eventually start to gain energy and will continue to do so. The problem has been studied in some detail for the case where the magnetic field and kinetic energy are both zero at $t = 0$. It appears that the kinetic energy T acquired by a proton which finds itself at the cylindrical radius r , where the average z component of magnetic

field is equal to $\bar{H}_z$ within that radius is such that $T > 150r\bar{H}_z$ electron volts. If $r \sim 25000$ light years, and $\bar{H} \sim 7 \times 10^{-6}$ gauss., $T \sim 2.3 \times 10^{19}$ eV. It also appears that the particle in its motion spirals outwards, inwards, or remains on a circle, according as $\bar{H}_z > 2H_z$; $\bar{H}_z < 2H_z$; $\bar{H}_z = 2H_z$, respectively, where H_z is the average z component within the radius r at which the z component of the magnetic field has the value H_z . If, in its journey through places where $\bar{H}_z \neq 2H_z$, the particle reaches a place where $\bar{H}_z = 2H_z$, then it will asymptotically approach a stable circular orbit for that value of r . A.

537.591.1 : 523.165

The outline of a theory to explain the origin of cosmic rays. See Abstr. 3396

537.591.1 : 539.166.835

Electron pairs in cosmic rays. See Abstr. 4042

537.591.15

3862. Penetrating showers from hydrogen and other elements. M. CERVASI, G. FIDECARO AND L. MEZZETTI. *Nuovo Cimento (Ser. 10)* **1**, No. 2, 300–13 (Feb., 1955).

The production of penetrating showers (p.s.) in paraffin, graphite, iron and lead by the fast nucleons of cosmic radiation at 3500 m above sea level has been investigated. The apparatus consists of a large area p.s.-detector and a large hodoscope of Geiger counters: its main features, as compared with the arrangements recently used by other authors, are a better angular resolution for the particles of the showers and the use of very thin production layers. The validity of the "difference method" to obtain the interactions in hydrogen from the comparison of the rates obtained with paraffin and carbon is discussed. From the rates obtained for hydrogen through this analysis and those found for graphite, iron and lead, the ratios of the interaction mean free paths for p.s. production are deduced. The cross-sections appear to follow closely the $A^{2/3}$ law (A = mass number), corresponding to the geometrical cross-section of the nuclei involved. Also the apparent cross-section for hydrogen is found to be little less than "geometrical" ($60 \times 10^{-27} \text{cm}^2$), in disagreement with what was found by other authors: the discrepancy is believed to be due to the differences in instrumental bias. The rates of the p.s. which appear to be generated in hydrogen by charged and neutral primaries are compared and discussed. The experimental results do not show any striking difference between the two cases, but an interpretation in terms of the elementary cross-sections for the pp and np interactions appear to be premature. A.

537.591.2

3863. On the spectrum of low-energy gamma rays in cosmic radiation. M. AGENO, G. CORTELESSA AND R. QUERZOLI. *Nuovo Cimento (Ser. 10)* **1**, No. 3, 453–67 (March, 1955) In Italian.

Using a NaI-crystal and a one-channel scintillation spectrometer, the energy spectrum of the ultra-soft component of the cosmic radiation at sea level has been studied in the open air and below 100 g/cm² concrete. This component is almost entirely made of secondary photons, mainly between 50 and 200 keV with a prominent peak near 80 keV in the air and

90 keV below concrete. The vertical incident intensity in the air is roughly 100 quanta/min. cm². sterad. The ultra-soft component is almost entirely isotropic, so the energy flux is about 1% of the total energy flux due to the cosmic radiation at sea level. The discontinuity of the absorption coefficient at the *K* critical absorption edge of Pb was shown by means of absorption measurements in this element, confirming the fact that the ultra-soft component is made of photons.

A.

537.591.3

3864. Study, using sensitive emulsions, of the absorption mean free path for the nuclear component in cosmic rays. Y. AVIGNON AND S. DESPREZ-REBAUD. *C.R. Acad. Sci. [Paris]* **240**, No. 5, 515–17 (Jan. 31, 1955) In French.

The mean free path for absorption of protons, with energies less than 190 MeV, has been found to be 123 ± 5 g/cm² of air. The measurements were carried out between altitudes of 160 metres and 1920 metres.

A. J. EGGINTON

537.591.5

3865. A note on the variation of cosmic ray intensity produced by an electric field. S. LUNDQUIST. *Tellus*, **6**, No. 3, 260 (Aug., 1954).

537.591.5

3866. Primary alpha particles in the cosmic radiation near the geomagnetic equator. M. A. POMERANTZ. *J. Franklin Inst.*, **258**, No. 6, 443–59 (Dec., 1954).

An apparatus consisting of a G.M. counter coincidence train in which is interposed a high-pressure ionization chamber has been utilized to obtain measurements of the flux of primary helium nuclei during a series of balloon-flights in India. The instrument records relativistic particles characterized by a specific ionization at least as great as that of an α -particle. The experiments were conducted at Aligarh, Uttar Pradesh (geomagnetic latitude 18°N) and Bangalore, Mysore (geomagnetic latitude 3°N). At each station, the intensity $N(I > 3 \cdot 2 I_{\min})$ of particles producing ionization chamber pulses exceeding the bias setting corresponding to $3 \cdot 2 I_{\min}$, plotted on a logarithmic scale as a function of atmospheric depth, follows a straight line. The intensity N_{total} was also measured by removing the criterion $I > 3 \cdot 2 I_{\min}$. Taking into account local nuclear interactions initiated by protons, knock-on electrons accompanying protons, and slow protons (albedo) which actuate the apparatus, the α -particle flux is determined from the extrapolated values of N_{total} and $N(I > 3 \cdot 2 I_{\min})$ at the "top of the atmosphere." The results are: 49 ± 13 particles m⁻² sec⁻¹ sterad⁻¹ at $\lambda = 3^\circ$ N, and 81 ± 22 particles m⁻² sec⁻¹ sterad⁻¹ at $\lambda = 18^\circ$ N. The qualitative effect of the presumably small systematic uncertainties is generally in the direction of making these values low. Both protons and helium nuclei can be represented by an integral energy distribution of the form: $N(>E) = k(1 + E)^{-1.2}$, where E is kinetic energy per nucleon; $k = 4000$ and $1.5 < E < 15$ BeV for protons; $k = 450$ and $0.3 < E < 7$ BeV per nucleon for α -particles. The composition of the primary cosmic radiation is not drastically different at $\lambda = 3^\circ$ and $\lambda = 18^\circ$, although the total intensity is anomalously high at the latter station.

A.

537.591.5

3867. World-wide cosmic-ray variations, 1937–1952. S. E. FORBUSH. *J. geophys. Res.*, **59**, No. 4, 525–42 (Dec., 1954).

Annual means from continuous registration of cosmic-ray ionization at four stations from 1937 to 1952 show a variation of nearly 4%, which is similar at all stations and which is negatively correlated with sunspot numbers. This variation in cosmic-ray intensity is quite similar for the annual means of all days, international magnetic quiet days, and international magnetic disturbed days, which indicates that it is not due to transient decreases accompanying some magnetic storms. Although the cosmic-ray intensity at some stations is affected by meteorological conditions, it is shown that on the average the cosmic-ray changes observed at Huancayo agree well with those at other stations. From an analysis of the variability of daily means at Huancayo and a sample comparison with Simpson's neutral data, it is concluded that the cosmic-ray ionization at Huancayo is very little affected by meteorological effects. Through a comparison with Neher's balloon observations, evidence is provided to indicate the reliability of cosmic-ray results at Huancayo over long periods of time. The relation between cosmic-ray decreases and some measures of geomagnetic activity is indicated, and it is shown that the major transient decreases in cosmic-ray intensity occur during magnetic disturbance. Graphs are included which depict the daily means of cosmic-ray intensity at Huancayo for all available data, 1937–1953.

A.

537.591.5

3868. The latitude effect and the E-W asymmetry of the nucleonic component of the cosmic rays. TSAI-CHÜ. *C.R. Acad. Sci. [Paris]* **240**, No. 3, 300–2 (Jan. 17, 1955) In French.

The observed latitude variation of secondary nucleons is shown to be in good agreement with that deduced from the primary spectrum. It is also shown that the observed E-W asymmetry is in good agreement with that expected from the latitude variation.

H. ELLIOT

537.591.8

3869. A study of stars produced in nuclear emulsions by cosmic rays at 1600 m and 4500 m near the equator. M. MORAND, L. WINAND AND C. BEETS. *Bull. Soc. Roy. Sci. Liège*, **23**, No. 9–10, 269–79 (Sept.–Oct., 1954) In French.

Gives the frequency distribution of stars per unit volume and as a function of the number of prongs. The mean free path for the star-producing radiation is found to be 220 g cm⁻² air.

H. ELLIOT

537.591.8

3870. On the slow particles come to rest in the nuclear emulsions at 23 m.w.e. underground. T. KUBOZOE, S. KANEKO AND M. TAKAHATA. *J. Inst. Polytech. Osaka City Univ. B*, **5**, No. 6, 25–35 (Oct., 1954).

Slow particles come to rest in the emulsion at a depth of 23 m.w.e. underground have been examined in Ilford G5 plates, coated, exposed and processed below ground. It is found that the absolute frequency

of μ -mesons stopped in the emulsion is $0.22 \pm 0.03 \text{ cm}^{-3} \text{ day}^{-1}$, which is greater than the value of George and Evans by a factor of about 2.5. It is also observed an appreciable number of slow protons come to rest in the emulsion. Considering the behaviour of their isotropic angular distribution, it seems to be certain that these protons are secondary particles produced underground. A.

537.591.8

3871. Unusual event produced by cosmic rays. E. AMALDI, C. CASTAGNOLI, G. CORTINI, C. FRANZINETTI AND A. MANFREDINI. *Nuovo Cimento (Ser. 10)* **1**, No. 3, 492–500 (March, 1955).

The event consists of two stars respectively of about 5 and 1–2 GeV energy. The probable value of the number of accidental space coincidences that one expects to observe in the scanned volume, is about 4×10^{-4} . This value, although it does not exclude an accidental process, justifies the consideration of interpretations in terms of some physical process. Special attention is devoted to the production, capture and annihilation of a negative proton. A.

MAGNETISM 538

538.082 : 621.317.412

3872. Investigation of the heterodyne beat method of measurement of magnetic susceptibility. H. G. EFFEMEY, D. F. PARSONS AND J. O'M. BOCKRIS. *J. sci. Instrum.*, **32**, No. 3, 99–102 (March, 1955).

A heterodyne beat method of determination of unstable free radicals has been investigated. A change in the magnetic susceptibility of a liquid placed inside the coil of an oscillating circuit causes a change of frequency which is measured by beating against a quartz crystal oscillator. The apparatus has been tested by determinations of paramagnetic salts and diamagnetic liquids. It is shown that the ultimate limitation on increasing the sensitivity is the temperature control of the free running oscillator. The modification of the apparatus for the detection of free radicals of half-life times down to 0.05 sec is discussed. A.

538.082.74 : 536.48

3873. Mutual inductance bridge and cryostat for low-temperature magnetic measurements. R. A. ERICKSON, L. D. ROBERTS AND J. W. T. DABBS. *Rev. sci. Instrum.*, **25**, No. 12, 1178–82 (Dec., 1954).

A mutual inductance bridge and cryostat are described which may be used to measure susceptibilities from 77°K, with liquid nitrogen, down to adiabatic demagnetization temperatures. In addition to the sensitivity necessary for measurements over such a temperature interval, the apparatus provides the following features: a usable frequency range of 100 kc/s, for the study of paramagnetic relaxation and paramagnetic specific heat; measurement of longitudinal susceptibilities in fields up to 3000 oersted, and transverse susceptibilities in fields up to 3000 oersted; a simple method for changing samples with a minimum dismantling of the equipment. A.

538.083.9

3874. A new method for the measurement of the distribution of magnetic fields. U. DOLEGA, H.

PFEIFER AND A. LÖSCHE. *Z. angew. Phys.*, **7**, No. 1, 12–13 (1955) In German.

Gives a brief account of a satisfactory method for measuring the field-strength distribution of an electromagnet using nuclear magnetic resonance.

E. P. WOHLFARTH

538.114

3875. Theory of the low temperature properties of ferromagnetic crystals. J. VAN KRANENDONK. Letter in *Physica*, **21**, No. 1, 81–2 (Jan., 1955).

The spin-wave treatment is generalized by considering the statistical mechanical properties of the partition function of the spin-wave assembly treated as a non-ideal Bose-Einstein gas. The temperature variation of the magnetization is calculated for a simple cubic lattice, both neglecting interaction between spin waves (leading to the $T^{\frac{3}{2}}$ law at low temperatures) and also taking account of binary collisions. The effect of such collisions is shown to be important, and the corresponding magnetization, temperature curve is shown to be in good agreement with the experimental curve for nickel at temperatures less than about 0.15 of the Curie temperature.

E. P. WOHLFARTH

538.114

3876. Antiferromagnetism. G. W. PRATT, JR. *Phys. Rev.*, **97**, No. 4, 926–32 (Feb. 15, 1955).

The nature of the spin coupling in MnO is discussed, the details of the discussion being based on a very simplified three-centre system. The coupling between magnetic ions whose charge densities interact with an intervening non-magnetic ion but not directly with each other is described as the result of the polarization of the non-magnetic ion. The configuration interaction representation of this polarization is treated by non-orthogonal orbitals, orthogonal orbitals, and by a method due to Kramers. These three approaches are applied to a numerical example. It is concluded that a reliable description of the simple three-centre problem is more complicated than generally believed due to the importance of highly excited states of the system which have been neglected in previous treatments of the problem. A.

538.221

3877. Magnetic powder patterns on cobalt and the structure of the elementary domains. W. ANDRÄ. *Ann. Phys. [Leipzig]* **15**, No. 2, 135–40 (1954) In German.

Gives results of powder pattern experiments on polycrystalline cobalt specimens with and without application of magnetic fields perpendicular to the surface. Maze patterns with attached spikes were observed. Conclusions are drawn as to the shape and dimensions of the domains inside the metal.

E. P. WOHLFARTH

538.221

3878. Possibility of the observation of exchange resonance near a ferrimagnetic compensation point. R. K. WANGSNES. Letter in *Phys. Rev.*, **97**, No. 3, 831–2 (Feb. 1, 1955).

Shows that near a compensation point the normal resonance peak is expected to shift to lower fields (g higher) while the exchange resonance peak appears at still lower fields and coincides with the first at

exact compensation. Above the compensation point the two peaks separate again. The results may also be expressed in terms of effective g values, the two branches of the curve of g as a function of temperature tending to coincide at the compensation temperature.

E. P. WOHLFARTH

538.221

3879. Observation of exchange resonance near a ferrimagnetic compensation point. T. R. MCGUIRE. Letter in *Phys. Rev.*, **97**, No. 3, 831-2 (Feb. 1, 1955).

Exchange resonance was observed on a small spherical specimen of $\text{Li}_{0.5}\text{Cr}_{1.75}\text{Fe}_{1.25}\text{O}_4$ and the general features of the predictions of the preceding abstract were verified. The compensation point was found to lie at about 57°C.

E. P. WOHLFARTH

538.221

3880. Ferromagnetic resonance absorption in colloidal suspensions. D. M. S. BAGGULEY. *Proc. Roy. Soc. A*, **228**, 549-67 (March 22, 1955).

Suspensions of pure metals and alloys have been investigated at wavelengths of 3.14 and 1.25 cm at 290°K. The g -factor for iron is measured to be 2.06 ± 0.02 and for nickel 2.22 ± 0.02 . In the nickel-iron alloys there appears to be a sharp anomaly near 40% Ni, where the g -factor falls to 2.01, and for alloys having between 50 and 85% Ni the g -factor is found to be 2.10 ± 0.02 . Apart from nickel there seems to be good agreement between $g - 2$ obtained from the microwave measurements and $2 - g'$ derived from gyromagnetic experiments. The half-width of the absorption line for iron is $700\text{Oe} \pm 10\%$. For the face-centred alloys the line width varies smoothly with a minimum value of about 300Oe near 70% Ni, where the magnetic anisotropy is least. It does not seem possible to assign the whole of the line width to spin-spin interactions of the type suggested by Kittel and Abrahams. A brief discussion of the g -factors for iron and nickel is given in terms of a localized electron model.

A.

538.221 : 518.5

3881. Magnetic materials for digital-computer components. I. A theory of flux reversal in polycrystalline ferromagnetics. N. MENYUK AND J. B. GOODENOUGH. *J. appl. Phys.*, **26**, No. 1, 8-18 (Jan., 1955).

It is proposed that magnetization reversal in polycrystalline ferro- and ferrimagnetic materials is primarily due to the nucleation and growth of the Bloch walls. The origin of domains of reversal magnetization is discussed. The rate of growth of these domains is determined by a study of the elastic and frictional forces which retard the motion of their 180°-Bloch-wall boundaries. This theoretical model successfully explains the output-voltage waveforms of polycrystalline materials. A figure of merit for the magnetization reversal of magnetic cores is defined as the switching coefficient $S_w = (H_m - H_0)\tau$, where τ is the time required to reverse the magnetization, H_m is the applied magnetic field, and H_0 is the threshold field value at which the average domain-wall velocity is zero. S_w is composed of an eddy-current contribution S_w^e and a spin-relaxation contribution S_w^r . The value of S_w is derived in terms of various fundamental parameters of the material. It is shown that in ferrites and ultra-thin metal tapes, $S_w^e \ll S_w^r$. Theoretical

relationships expressing the contributions of spin-relaxation, eddy-current, and hysteresis effects to energy losses are derived on the basis of this model. A study of the factors which affect the magnetization-reversal time of materials with square hysteresis loops indicates that a better figure of merit will result if the proper hysteresis shape is obtained by grain alignment rather than by the techniques currently employed in ferrites. A number of experiments are presented in support of this model.

A.

538.221 : 538.24

3882. Domains of reverse magnetization in ferromagnetic metals. T. G. NILAN AND W. S. PAXTON. Letter in *Phys. Rev.*, **97**, No. 3, 834-5 (Feb. 1, 1955).

Powder pattern experiments on laminated 34% Si steel show that the observed closure and reverse magnetization domains are characteristic of the orientations of the crystal grains relative to the plane of the sheet and the rolling direction and are not influenced by the orientation of neighbouring grains as suggested by Goodenough [Abstr. 10344 (1954)]. For demagnetized samples the type of pattern depends entirely on the angle between the plane of the sheet and the plane containing the easy axis, the grain boundary energy having little influence on the nucleation of domains of reverse magnetization.

E. P. WOHLFARTH

538.221 : 538.652

3883. The temperature dependence of magnetostriction in a nickel crystal. W. D. CORNER AND G. H. HUNT. *Proc. Phys. Soc. [London] A*, **68**, Pt 3, 133-44 (March, 1955).

From a single crystal of nickel two specimens have been prepared in the form of prolate spheroids whose major axes lie along the [100] and [111] crystallographic directions. By the use of a special capacitance bridge arrangement [Abstr. 772 (1955)], the longitudinal magnetostriction of each specimen has been measured over the temperature range -180°C to 360°C . The results obtained indicate that at low temperatures the magnetostriction below saturation varies with magnetization approximately in the manner given by the domain treatment suggested by Heisenberg, and that with increasing temperature there is a steady departure from the calculated values. The saturation magnetostriction was found to depend on temperature in a way which did not correspond to any known theory.

A.

538.221 : 550.38

3884. Interaction of two constituents in ferromagnetic materials showing reverse thermo-remanent magnetism. T. NAGATA AND S. UYEDA. Letter in *Nature [London]* **175**, 35-6 (Jan. 1, 1955).

A continuation of earlier work on the magnetic properties of igneous rocks [Abstr. 5192 (1952), 593, 1475 (1954)]. The reversal phenomenon is believed to be due to the effect of the intimate interaction of the two ferromagnetic constituents A and B having different Curie points. For the Haruna dacites the two constituents are found in fact to interpenetrate closely, the interpenetrating particles being in the form of narrow, probably single domain strips. For dacites from Asio and Towada the thermo-remanent magnetization is not reverse and the interaction between constituents is weaker.

E. P. WOHLFARTH

- 538.222
3885. Paramagnetic resonance in low fields. G. J. BÉNE AND R. C. EXTERMANN. Letter in *Phys. Rev.*, **97**, No. 1, 238 (Jan. 1, 1955).

Points out that the theory of Garstens [Abstr. 5802 (1954)] is closely related to that published previously by the authors [*Arch. Sci. (Geneva)* **4**, 436 (1951)].

D. H. WHIFFEN

- 538.222
3886. Paramagnetic resonance from broken carbon bonds. J. E. BENNETT, D. J. E. INGRAM AND J. G. TAPLEY. Letter in *J. chem. Phys.*, **23**, No. 1, 215 (Jan., 1955).

An absorption line obtained from carbohydrates and other organic materials charred slowly below 600°C is exactly the same as that obtained from coal. Its width is 8 ± 2 gauss., and g for it is 2.0030 ± 0.0003 , at frequencies from 40 to 36000 Mc/s and temperatures 20–290°K. It is ascribed to broken bonds in aromatic rings.

J. HAWGOOD

- 538.222
3887. Paramagnetic resonance in copper phthalocyanine. J. E. BENNETT AND D. J. E. INGRAM. Letter in *Nature [London]* **175**, 130–1 (Jan. 15, 1955).

- 538.222
3888. On the dependence of the constants in the Curie-Weiss law on exchange. C. M. HERZFELD. Letter in *J. chem. Phys.*, **23**, No. 2, 398–9 (Feb., 1955).

Analyses magnetic susceptibility data for a number of paramagnetic compounds in solid solution with isomorphous diamagnetic compounds to determine whether the Curie-Weiss constant is affected by the concentration of the paramagnetic ions, i.e. by exchange. Such a dependence is in general deduced from the analysis, but may be weak if the orbital angular momentum of the paramagnetic ion is only slightly quenched or when it is nearly zero.

E. P. WOHLFARTH

- 538.222
3889. Paramagnetic resonance absorption in chromic chloride. YU TING, L. D. FARRINGER AND D. WILLIAMS. *Phys. Rev.*, **97**, No. 4, 1037–8 (Feb. 15, 1955).

Powdered anhydrous chromic chloride has been re-examined at a frequency 9308 Mc/s. The line width between points of maximum slope was found to be 79 gauss.; the line width at half-height was 148 gauss.; and the measured root-mean-square width was 103 gauss. The line width at half-height is considerably smaller than the width calculated for dipole-dipole broadening on the assumption of a Gaussian line shape. The effective g value was found to be 1.997 ± 0.003 .

A.

- 538.222 : 536.48
3890. On paramagnetic relaxation in the temperature region of liquid helium. C. J. GORTER, L. C. VAN DER MAREL AND B. BÖLGER. *Physica*, **21**, No. 2, 103–9 (Feb., 1955).

While paramagnetic relaxation on the whole has found satisfactory theoretical description, the data obtained at liquid helium temperatures are in several

respects anomalous and in disagreement with the expectations. These data are also in conflict with recent observations on the saturation of microwave absorption. On the basis of a suggestion, rejected in 1941 by Van Vleck, it is argued that the bottleneck observed in the relaxation experiments at liquid helium temperatures may be the heat contact between a small group of low frequency crystal oscillators in contact with the magnetic spin system, on the one hand, and the constant temperature bath, on the other. A very provisional analysis of this possibility leads to reasonable agreement with the available data.

A.

- 538.222 : 537.525
3891. Electron resonance in gas discharges. D. J. E. INGRAM AND J. G. TAPLEY. Letter in *Phys. Rev.*, **97**, No. 1, 238–9 (Jan. 1, 1955).

Describes preliminary results obtained with a paramagnetic resonance technique involving a gaseous discharge in a cavity resonator. Absorption lines, with half-widths ~60–200 gauss, were observed in air, argon, oxygen and carbon dioxide. Possible causes of the absorption lines are briefly discussed.

J. D. CRAGGS

- 538.27 : 538.6 : 536.7
3892. Thermodynamical theory of galvanomagnetic and thermomagnetic phenomena. R. FIESCHI. *Nuovo Cimento Suppl. (Ser. 10)* **1**, No. 1, 1–47 (1955).

A review of an application of the thermodynamics of irreversible processes. De Groot and Mazur's treatment is outlined. The reciprocal relations are derived for thermal conduction; diffusion and viscosity in the presence of an electromagnetic field. Galvanomagnetic and thermomagnetic phenomena in anisotropic metals are discussed and explicit relations for the observable coefficients in isotropic metals are derived. The treatment is extended to the Peltier effect in the presence of a magnetic field.

E. P. WOHLFARTH

ELECTROMAGNETISM . ELECTRODYNAMICS

538.3/.5

- 538.3
3893. Energy of the harmonic oscillator in vacuo. P. BRAFFORT AND C. TZARA. *C.R. Acad. Sci. [Paris]* **239**, No. 25, 1779–80 (Dec. 20, 1954) In French.

See Abstr. 10347 (1954). Remaining in the field of classical physics, it is found that the energy of a harmonic oscillator in the fluctuating field of the absorber is equal to the product of its frequency times a universal constant.

L. PINCHERLE

- 538.3 : 537.12
3894. On the equation of the positron in classical electrodynamics. P. CALDIROLA. Letter in *Nuovo Cimento (Ser. 10)* **1**, No. 2, 347–51 (Feb., 1955) In Italian.

A continuation of previous work [Abstr. 4735 (1954), 732 (1955)]. The equation of motion is studied and related to work by Feynman. The self-energy is calculated.

L. S. GODDARD

ELECTROMAGNETIC WAVES AND
OSCILLATORS 538.56

538.565 : 621.372.413 : 621.317.324

3895. A method of measuring the intensity distributions of radio-frequency electric and magnetic fields in resonant cavities. J. G. LINHART AND T. H. B. BAKER. *Brit. J. appl. Phys.*, **6**, No. 3, 100-3 (March, 1955).

A method is described for determining the intensity distributions in terms of the changes in both the resonant frequency and the Q -factor, caused by the placing of a small spherical bead of dielectric or ferromagnetic material at the relevant points in the cavity.

A.

538.566

3896. On electromagnetic fields in case of existence of a semi-infinite hollow conductive circular cylinder. II. T. IJIMA. *Researches Electrotech. Lab. [Tokyo] No. 531*, 214 pp. (1952) In Japanese.

Considers the problem of the diffraction of electromagnetic waves, by methods other than the approximate methods of Kirchhoff and Huygens. The problem considered is that of an open-ended rigid circular pipe of negligible wall thickness and of perfect conductivity. A rigorous solution of the problem of the vector field which is irreducible to that of the single scalar field, has been obtained. The problem of a linearly polarized monochromatic plane wave, incident upon a circular pipe from free space, is then considered.

D. W. MORTIFEE

538.566 : 538.632 : 621.315.59 : 621.317.38

3897. The application of the Hall effect in a semiconductor to the measurement of power in an electromagnetic field. H. E. M. BARLOW. *Proc. Instn Elect. Engrs Paper No. 1654 M*, publ. June, 1954 (**102 B**, 179-85, 199-203).

Republication, with discussion, of the paper abstracted in Abstr. 7584 (1954).

538.566

3898. The diffraction of a non-monochromatic electromagnetic wave by a slit and a grating. M. H. N. POTOK. *Proc. Phys. Soc. [London] B*, **68**, Pt 3, 171-6 (March, 1955).

A general solution is derived from Kirchhoff's solution. The results of measurements agree well with calculations in the range where Kirchhoff's solutions can be accepted.

A.

538.566 : 621.396.677 : 621.317.324.029.6

3899. Measurement of microwave diffraction from a long slit in a thin conducting plane. J. L. HIRSHFIELD AND C. M. ZIEMAN. *J. appl. Phys.*, **26**, No. 2, 135-7 (Feb., 1955).

Gives the results of measurements of the fields diffracted from a long narrow slit in a large conducting plane, when a uniform plane is incident. The results for two polarizations are shown.

A.

538.566 : 621.396.677 : 621.396.11

3900. Diffraction by apertures. C. HUANG, R. D. KODIS AND H. LEVINE. *J. appl. Phys.*, **26**, No. 2, 151-65 (Feb., 1955).

The diffraction of plane electromagnetic waves by

apertures in a plane screen which is infinitesimally thin and perfectly conducting is studied both theoretically and experimentally. The theoretical analysis employs a dyadic Green's function to develop vector formulae for the scattered fields, and from these formulae integral equations are obtained for the aperture distributions. The vector representation makes possible a compact demonstration of the electromagnetic form of Babinet's principle by means of which one may extend the aperture analysis to complementary disks. The integral equations are then used to construct a variational principle for the aperture transmission coefficient. Detailed analysis and numerical computations are carried out for two configurations. For the circular aperture a first-order vector trial function with frequency dependent coefficients is chosen for the aperture distribution. The approximate transmission coefficient is found to agree closely with the exact value in the region $2\pi a/\lambda \leq 3$. For elliptical apertures a zeroth-order approximation is evaluated using a one-component trial function. Numerical results are given for minor-to-major axis ratios of $\frac{1}{2}$ and $\frac{1}{3}$. Transmission coefficient measurements were carried out in the 24000 megacycle band ($\lambda = 1.25$ cm) using an image plane technique. The apparatus was first calibrated with the exact solution of the circular aperture. The approximate results calculated for elliptical apertures are then seen to be in good agreement with the measurements over the accessible range.

A.

538.566

3901. On the theory of circularly symmetric TM waves in infinite irisloaded guides. C. C. GROSJEAN. *Nuovo Cimento (Ser. 10)* **1**, No. 3, 427-38 (March, 1955).

The exact theory of propagation in guides with perfectly conducting walls is worked out and discussed in detail, starting with two arbitrary functions in the description of the E_z component at the corrugation mouths and making use of the well-known Floquet theorem. The final equations form an infinite linear system which can be transformed in several interesting ways leading to new formulae, but has not yet been solved explicitly.

A.

538.566

3902. Mathematical transformation of a system of equations appearing in the theory of TM wave propagation in corrugated guides. C. C. GROSJEAN. *Nuovo Cimento (Ser. 10)* **1**, No. 3, 439-46 (March, 1955).

Generalizing the method of the preceding abstract, an infinite system of equations appearing in a problem of wave propagation through periodically iris-loaded guides, has been exactly transformed into a new system of equations which may be of interest for the further solution of the problem.

A.

538.566

3903. On the (β_0, k) diagrams for circularly symmetric TM waves in infinite irisloaded waveguides. V. J. VANHUYSE. *Nuovo Cimento (Ser. 10)* **1**, No. 3, 447-52 (March, 1955).

Due to simplifications in the final equations of the theory of circularly symmetric TM-waves in infinite iris-loaded waveguides, arising in the case of guides with infinitely thin irises, the results can be brought

directly in connection with the pass bands in the different (β_0, k) diagrams (frequency v , propagation constant). A.

538.566 : 621.372.8

3904. Propagation constant in rectangular waveguide of finite conductivity. D. M. KERNS AND R. W. HEDBERG. Letter in *J. appl. Phys.*, **25**, No. 12, 1550-1 (Dec., 1954).

Gives a first-order expression for the propagation constant of the lowest mode in a rectangular waveguide having walls of finite conductivity. The expression is valid both above and below cut-off.

G. D. SIMS

538.566

3905. Calculated patterns of circumferential slots on a circular conducting cylinder. J. R. WAIT AND S. KAHAN. *Canad. J. Technol.*, **33**, No. 1, 77-97 (Jan., 1955).

Extensive computations are presented for the radiated fields of thin half-wave circumferential slots cut on a circular conducting cylinder of infinite length.

A.

538.566.3

3906. Non-Maxwellian theory for homogeneous and anisotropic plasmas. R. JANCEL AND T. KAHAN. *Nuovo Cimento*, **12**, No. 5, 573-612 (Nov., 1954) In French.

A method for solving the Boltzmann integro-differential equations, established by the authors, is applied to the theory of anisotropic ionized gases (in a constant magnetic field) for non-Maxwellian states. In this way explicit expressions may be obtained for the magnetic-ionic conductivity, the dielectric tensor, the Hall tensor, the derivation of a cloud of electrons and for a generalization of Langenin's mobility formula. A comparison is given between these results with those obtained by other methods of calculation (based on the mean free path). The propagation of plane electromagnetic waves in such a plasma is studied; and in particular formulae are established for refractive index, birefringence, phase and group velocity, attenuation, polarization of the waves and limiting frequencies. By means of certain approximations, the validity of which is discussed, the results of classical relativity theory of the ionosphere are recovered.

A. V. BREHME

538.566.3

3907. General expression for the absorption of electromagnetic waves in a Lorentzian plasma (ionosphere). M. LOZZI, R. JANCEL AND T. KAHAN. *C.R. Acad. Sci. [Paris]* **240**, No. 2, 162-4 (Jan. 10, 1955) In French.

Mathematical appendix to previous papers [Abstr. 6745 (1954) and preceding abstract] giving general expressions for the absorption coeff. for the ordinary and extraordinary waves.

G. M. BROWN

538.566.3

3908. An ionospheric attenuation equivalence theorem. E. APPLETON AND W. J. G. BEYNON. *J. Atmos. terrest. Phys.*, **6**, No. 2-3, 141-8 (March, 1955).

The phenomenon of radio-wave attenuation by way of ionospheric partial reflections and scattering is examined theoretically, and an equivalence theorem, relating oblique incidence to vertical-incidence phenomena, is derived. For radio frequencies well in excess

of the equivalent critical frequency of the medium this may be written

$$\left[\rho \right]_{i_0}^f = \lambda \left[\rho \right]_0^{f \cos i_0}$$

where ρ is the fractional attenuation, f is the frequency, and i_0 the angle of incidence in the oblique-incidence case. Where the radio-wave electric vector is at right angles to the plane of propagation, λ is unity; when the electric vector lies in the plane of propagation, λ is equal to the usual obliquity factor $\cos 2i_0$. A.

538.567

3909. Vacuum fluctuation noise and dissipation. J. WEBER. *Phys. Rev.*, **96**, No. 3, 556-9 (Nov. 1, 1954).

An electron beam interacting with the fields in an enclosed region is considered. The induced noise caused by the vacuum fluctuations and the thermal fluctuations is calculated in terms of the dissipation function $R(\omega)$ and the electron transit time τ . An expression is developed for the observable mean squared electromotive force, which is employed to calculate the fluctuations induced in an electron beam interacting with a damped electrical oscillator. The results are valid even if the oscillator is heavily damped. As the damping becomes very large the fluctuations are shown to approach zero. For a weakly damped oscillator the fluctuations reduce to those already given in an earlier paper [Abstr. 6743 (1954)]. The differential form of the fluctuation dissipation theorem is shown to be very useful for the evaluation of matrix elements. A.

538.569 : 536.6 : 621.317.784.029.6

3910. A microwave microcalorimeter. A. C. MACPHERSON AND D. M. KERNS. *Rev. sci. Instrum.*, **26**, No. 1, 27-33 (Jan., 1955).

Describes a calorimeter for the measurement of microwave power with relatively high accuracy (better than 1%) and at low (milliwatt) power levels. The calorimeter is identifiable as an electrically (d.c.) calibrated, aneroid micro-calorimeter of the Joule twin type. A bolometer mount assembly serves as a waveguide termination for the absorption of microwave power and constitutes the calorimetric body whose temperature rise is observed. This arrangement enables the use of a novel indirect measurement technique and tends to insure calorimetric equivalence of d.c. and r.f. heating. The equivalence error is investigated with the aid of heat flow analysis and auxiliary experiments, and an upper bound for the error is assigned. A.

MOLECULAR AND ATOMIC STRUCTURE

539.1

THEORY OF SOLID STATE 539.11

539.11

3911. On the calculation of the electrostatic binding energy of finite heteropolar crystals. C. CHRISTOV. *Ann. Phys. [Leipzig]* **15**, No. 2, 112-23 (1954) In German.

The energy of a cubic NaCl crystal is a function of the number of ions along any edge. This function

can be expressed as the sum of two functions one of which is only pseudo-convergent, the other rapidly convergent. A method of summation is given.

C. A. HOGARTH

539.11

3912. Orthogonalized plane wave method. J. CALLAWAY. *Phys. Rev.*, **97**, No. 4, 933-6 (Feb. 15, 1955).

Difficulties in application of the orthogonalized plane-wave method of determining energy levels in solids may arise under two conditions: If (1) the potential around an atom in the crystal is appreciably different from that of a free atom; or if (2) the wave-function for a valence electron state is orthogonal by reasons of symmetry to all core states. Ways of treating these problems are discussed, and applied to two eigenvalues in iron.

A.

539.11

3913. Theory of impurity bands with randomly distributed centers. P. AIGRAIN. *Physica*, **20**, No. 11, 978-82 (Nov., 1954).

The strong-binding approximation is applied to the calculation of the eigenvalues for impurity centres when the impurity density is high and interaction between different centres is not negligible. The method has also been applied to impurity bands in semiconductors.

A. E. DE BARR

539.11

3914. On the problem of radiationless transitions. H. HAKEN. *Physica*, **20**, No. 11, 1013-16 (Nov., 1954).

A novel approach different from the usual perturbation theory and the Born-Oppenheimer approximation is made which allows a rigorous solution of Schrödinger's equation for interaction of electron and lattice vibrations, the impurity centre being represented by a Dirac δ -function. Increase in coupling lowers the energy and separation between phonon energy states becomes smaller. Under such conditions many phonon transitions are shown to be possible, e.g. for an electron binding energy of 0.1 eV the transition probability for a 4 phonon transition is at least 10^4 times higher than for the Born-Oppenheimer approximation.

G. F. J. GARLICK

539.11

3915. A new formulation of the method of nearly free electrons. E. ANTONČÍK. *Czech. J. Phys.*, **4**, No. 4, 439-52 (Nov., 1954).

It is shown that the method of nearly free electrons can be used to compute the energy spectra of the valence electrons in metals if we require that the wave-functions of the valence electrons be orthogonal to the wave-functions of the ion electrons of the metal. The orthogonality condition is here replaced by a repulsion potential. The energy values of some characteristic points in the first and second Brillouin zones of Na, K, Rb and Cs are calculated.

A.

539.11

3916. Exciton multiplicities. R. E. MERRIFIELD. Letter in *J. chem. Phys.*, **23**, No. 2, 402 (Feb., 1955).

Theoretical discussion of the effect of spin on exciton properties, pointing out that non-diagonal matrix elements, affecting properties like band width and velocity of propagation, will be much larger for singlet than for triplet states.

J. HAWGOOD

539.11 : 548.7

3917. Theory of the electronic polaron and ionization of a trapped electron by an exciton. Y. TOYOKAWA. *Progr. theor. Phys.*, **12**, No. 4, 421-42 (Oct., 1954).

Introduces the concept of the electronic polaron which is an analogue of the usual lattice polaron, and considers its motion under the influence of a trapping potential, by using a simplified model for the electronically polarizable crystal such that the excited states of crystal electrons consist of a single exciton band. By a suitable transformation an expression is obtained for the Hamiltonian which consists of the following three parts: the first part describes the motion of an electron under the potential in a dielectric medium in the classical way, the second represents the energy of the electronic polarization field the quanta of which are nothing but free excitons, and the last part is the interaction energy between these two parts which causes the production or annihilation of excitons in the neighbourhood of the potential by exchanging energy with the electron. Treating the last part as a perturbation, the probability for the ionization of a trapped electron by an exciton is calculated. After correcting the over-simplification of the model, the obtained result has been applied to actual crystals, leading to the conclusion that in alkali halides the excitons annihilate rather by ionizing F-electrons than by spontaneous emission if the density of the F-centres is larger than 10^{16} per cm^3 , in consistence with the experimental results of Apker and Taft on the external photoelectric effect.

A.

539.11 : 548.7

3918. Theoretical determination of the electronic band structure of polyatomic crystals. L. PINCHERLE. *Physica*, **20**, No. 11, 965-7 (Nov., 1954).

A short review stressing some advantages of the cellular method in this type of calculation.

A.

539.11 : 548.7

3919. The electronic band structure of silicon. D. P. JENKINS. *Physica*, **20**, No. 11, 967-70 (Nov., 1954).

In addition to results already reported [Abstr. 8473 (1954)], the energy curves are given in the (1, 0, 0)-direction of reciprocal space. The valence band is found to have its maximum at the origin, while the minimum of the conduction band is found to occur at a value of k not very far from the zone boundary. These results are in agreement with the band structure deduced from various experimental evidence, but the two bands are given by the calculation as overlapping, indicating that the potential used was not an adequate approximation.

L. PINCHERLE

539.11

3920. Temperature dependence of the energy-gap in ZnS. C. Z. VAN DOORN. *Physica*, **20**, No. 12, 1155-6 (Dec., 1954).

The shift of the lattice absorption spectra with temperature is measured for a single ZnS crystal from 77°K to 878°K. The gap between valence and conduction band varies with a rate of 4.6×10^{-4} eV/deg K at 77°K to 8.5×10^{-4} eV/deg K at 800°K in agreement with earlier measurements on powder specimens.

G. F. J. GARLICK

539.11 : 537.531 : 535.33/.34

3921. X-ray spectroscopy of the solid state: potassium chloride. L. G. PARRATT AND E. L. JOSSEM. *Phys. Rev.*, **97**, No. 4, 916–26 (Feb. 15, 1955).

The experimental *K* spectral regions of potassium and chlorine in crystalline KCl have a much more complex array of structure, both in emission and in absorption; than can be explained by the conventional energy level diagram for the solid state. The pertinent spectral region is that which involves the valence and conduction bands of the solid. The difficulties seem to arise from a theoretical preoccupation with one-electron transitions. Consideration of the various probable electron configurations of the many-electron solid system shows several additional initial (1s vacancy) and final (outer vacancy) states. The charge density in the outer electron bands, suddenly confronted with the problem of screening the excess positive charge attending a 1s vacancy (or any inner vacancy), redistributes itself, distorting the bands and establishing one or more local discrete levels below each band. With the most probable filled discrete level below the 3*p* band, the narrow intense *Kβ*₁ line is explained but it is necessary to account somehow for the very narrow final state (3*p* vacancy). An obvious conclusion is that the 3*p* valence band itself is therefore very narrow in energy, only 0.33 eV wide. However, if it is indeed wider than this, as is commonly believed in the lore of solid state physics, the *Kβ*₁ emission must be restricted by some (unknown) mechanism to a small energy region within the band. In this event, X-ray emission involving the entire broad 3*p* band may be part of the observed faint emission on the high energy side of the *Kβ*₁ line, and, if so, the restricted energy position just mentioned must be at the bottom of the band. Also a consequence of the 1s vacancy are several normally empty discrete levels below and in the conduction band of KCl. With these levels, the narrow intense *K* absorption lines are explained. The discussion given is primarily experimental and phenomenological. The qualitative agreements are perhaps compatible with either a narrow or a wide 3*p* band for both potassium and chlorine in KCl, but show a preference for the wide 3*p* band. Either conclusion dictates the need of a new quantitative theoretical treatment.

A.

MOLECULES 539.13

539.13

3922. Transition probability in molecular encounters. I. The evaluation of perturbation integrals. T. L. COTTRELL AND N. REAM. *Trans Faraday Soc.*, **51**, Pt 2, 159–71 (Feb., 1955).

The object was to evaluate the perturbation integral for transitions between internal states produced by encounters between two molecules, with particular reference to the effect of choosing alternative functions to represent intermolecular force. The numerical work was restricted to an investigation of the excitation of the 1306 cm⁻¹ vibration in methane, the intermolecular potential being represented by the (12 : 6) and (9 : 6) Lennard-Jones functions or by a Morse function, but the methods are of general application.

It may be concluded that for molecules with a spherically symmetrical potential, a comparison of the perturbation integrals resulting from different force functions can be based on direct encounters alone, that the second virial coefficient gives almost no information about the intermolecular force at distances small enough to affect the perturbation integral, and that the relevant distances are sufficiently short to make questionable the assumption that the centre of force is at the centre of mass. The validation of first-order perturbation theory, which depends on the perturbation being small, may require examination of the behaviour of the perturbation integral throughout the encounter.

A.

539.13

3923. Intermolecular force field of linear molecules with quadrupole moments. A. D. BUCKINGHAM. Letter in *J. chem. Phys.*, **23**, No. 2, 412 (Feb., 1955).

Theoretical. An expression due to Pople [Abstr. 4777–8 (1954)], for the temperature dependence of the second virial coefficient of an assembly of axially symmetric molecules, is applied to N₂ and CO₂, using a successive approximation method. Agreement with experiment is reasonable.

J. HAWGOOD

539.13

3924. Vibrational relaxation in polyatomic gas (methane). T. INOUE AND T. TAKAHASHI. *J. Phys. Soc. Japan*, **10**, No. 3, 208–18 (March, 1955).

A method for obtaining an expression of the intermolecular potential including internal co-ordinates is proposed. The potential is assumed to be the sum of interatomic potentials. The calculation is carried out for the CH₄–CH₄ interaction and vibrational relaxation times for *v*₄, *v*₂ and *v*₁ are calculated. It is shown that *v*₄ relaxation time corresponds to the value obtained by Eucken and Aybar and is the decisive value in supersonic dispersion as in their experiment.

A.

539.13

3925. On the state of solid hydrogen. K. TOMITA. *Proc. Phys. Soc. [London] A*, **68**, Pt 3, 214–28 (March, 1955).

Co-operative appearance of the rotation of hydrogen molecules in the solid phase is described using a semi-classical theory. The order of magnitude of the restriction to the rotation which is experienced by a molecule at the lowest temperature is estimated to be about 4°K using several different types of experiments, and the results are in reasonable agreement with each other. For the case of pure ortho-hydrogen a calculation of the potential energy and the anisotropy based on intermolecular forces is carried out in the Appendix.

A.

539.132

3926. Force constants for methyl cyanide and methyl isocyanide. S. L. N. G. KRISHNAMACHARI. *Indian J. Phys.*, **28**, No. 10, 463–8 (Oct., 1954).

Force constants have been determined using the Wilson *F*–*G* matrix method. The CN stretching force constant changes from 17.98 for CH₃CN to 16.43 for CH₃NC, the CC stretching force constant changes from 5.131 for CH₃CN to 5.322 for CH₃NC, the CCN bending force constant changes from 0.1237

for CH_3CN to 0.07731 for CH_3NC while the force constants of the methyl group remain very nearly the same for the two molecules. A.

539.132

3927. Predissociations of the C^{12}O and C^{13}O molecules. A. E. DOUGLAS AND C. K. MÖLLER. *Canad. J. Phys.*, **33**, No. 3-4, 125-32 (March-April, 1955).

The Ångström bands of C^{12}O and C^{13}O have been photographed with a high dispersion spectrograph and the predissociations previously reported in these bands have been re-examined. The predissociations provide good evidence that C^{12}O has a dissociation limit $89\,595 \pm 30\text{ cm}^{-1}$ above the $v = 0$ level of the ground state. The fourth positive ($A^1\Pi-X^1\Sigma$) bands have been re-examined and it has been shown that, contrary to earlier reports, there is no evidence for predissociation in the $A^1\Pi$ state. A.

539.132 : 535.333

3928. Recent spectroscopic studies of simple molecules. A. E. DOUGLAS. *J. phys. Chem.*, **59**, No. 2, 109-10 (Feb., 1955).

A summary of some recent work on the dissociation energies of O_2 , N_2 , CO and CN . A.

539.132

3929. Study of Hulbert-Hirschfelder $U(r)$ function in C_2 (Swan) system. N. R. TAWDE AND K. GOPAL-KRISHNAN. *Indian J. Phys.*, **28**, No. 10, 469-72 (Oct., 1954).

The rôle of Hulbert-Hirschfelder potential energy expression to predict the most probable transitions in vibrational levels has been examined in relation to the expressions of Morse and Rydberg. These predictions are critically discussed in the light of the results of the theoretical treatments of Hutchisson, Pillow, Bates and Wyller and results of precise experimental observations. A.

539.132

3930. Pure rotation lines of OH. R. P. MADDEN AND W. S. BENEDICT. *J. chem. Phys.*, **23**, No. 2, 408-9 (Feb., 1955).

The fine structure of the OH rotation lines $K'' = 13 - 18$ could be resolved by the use of a grating spectrometer. The emission spectrum was taken between 490 and 660 cm^{-1} . All possible lines appear at the frequencies calculated. The lines appear in groups of 4, due to Δ and spin doubling. The intensities found also agree with calculated values. The dipole moment of OH is expressed as a function of the $\text{OH}/\text{H}_2\text{O}$ concentration ratio. This ratio is estimated from a number of H_2O lines present, and μ_{OH} is found to be $1.54 D$. A. J. TAYLOR

539.132 : 535.343

3931. Structure and barrier to internal rotation of formic acid from microwave data. R. G. LERNER, J. P. FRIEND AND B. P. DAILEY. Letter in *J. chem. Phys.*, **23**, No. 1, 210 (Jan., 1955).

The best fit with microwave absorption lines ignoring distortion effects is obtained with $\text{C-H } 1.085$, $\text{C-O } 1.245$, $\text{C-O } 1.312$ and $\text{O-H } 0.95 \text{ Å}$, $\angle \text{OCO } 124^\circ 18'$, $\angle \text{COH } 107^\circ 48'$, $\angle \text{HCO } 117^\circ 51'$ and OH torsional frequency of 667 cm^{-1} , which latter quantity is obtained from an intensity ratio. D. H. WHIFFEN

539.132 : 536.75

3932. Barrier hindering internal rotation in methylamine. J. G. ASTON AND F. L. GITTLER. Letter in *J. chem. Phys.*, **23**, No. 1, 211-12 (Jan., 1955).

The entropy of methylamine obtained from the equilibrium constant of $\text{CH}_3\text{NH}_2 + \text{HCl}$ from cell e.m.f. measurements in ethyl alcohol, agrees well with the spectroscopic value if the energy barrier is $1\,900\text{ cal. mole}^{-1}$. D. H. WHIFFEN

539.132 : 541.63

On the structure of sym-tetrabromoethane. See Abstr. 4156

539.132

3933. The ground-state of the hydrogen molecule. B. KOCKEL. *Ann. Phys. [Leipzig]*, **15**, No. 2, 64-78 (1954) In German.

A comparison of some eigenfunctions which have been used for H_2 . Eigenfunctions based on elliptic co-ordinates are better than those built from H-atomic wave-functions with or without screening. Here "better" means that better bond energy values are obtained for the same number of variable parameters. J. JACOBS

539.132

3934. Approximate solutions of the Thomas-Fermi equation for molecules. II. H. C. BRINKMAN AND B. PEPPERZAK. *Physica*, **21**, No. 1, 48-52 (Jan., 1955).

The method of solving the Thomas-Fermi equation, developed in Pt I [Abstr. 4762 (1954)] is applied to the H_2O -molecule. The electronic density is calculated. A proof is given that the Thomas-Fermi method, or generally any method, which treats the electrons as a continuous cloud of electricity obeying the Poisson equation, gives a zero value for the electric dipole moment of any molecule. A.

539.132

3935. Excitation of molecules in the beta decay of a constituent atom. H. M. SCHWARTZ. Letter in *J. chem. Phys.*, **23**, No. 2, 400-1 (Feb., 1955).

Theoretical. Discusses approximate evaluation of transition probabilities for vibrational and electronic excitation accompanying β -decay, in particular for light diatomic molecules and for heavy molecules. J. HAWGOOD

539.132

3936. Theory of the fine structure of the molecular oxygen ground state. M. TINKHAM AND M. W. P. STRANDBERG. *Phys. Rev.*, **97**, No. 4, 937-51 (Feb. 15, 1955).

A rather complete solution for the fine-structure problem in the oxygen molecule is given in the framework of the Born-Oppenheimer approximation. The reduction of the effect of the electronic state on the fine structure to an effective Hamiltonian, involving only the resultant electronic spin in addition to rotational and vibrational quantum numbers, is demonstrated. In this Hamiltonian the parameters λ and μ measure the effective coupling of the spin to the figure axis and the rotational angular momentum, respectively. The contributions to these parameters which are diagonal in electronic quantum numbers, namely λ' and μ' , are evaluated by using an expression

for the electronic wave-function as a superposition of configurations. It turns out that λ' gives almost all of λ , whereas μ' gives only 4% of μ . The second-order contributions of spin-orbit coupling and rotation-induced electronic angular momentum to λ and μ , and the electronic contribution to the effective moment of inertia are related to each other and to certain magnetic effects to be given later. This interrelation enables them all to be essentially evaluated experimentally. The effective Hamiltonian is diagonalized through terms in $(B/\hbar\omega)^2$ and the eigenvalues compared with the experimental spectra. The fitting establishes the constants: $\mu = 252.67 \pm 0.05$ Mc/s; $\lambda_e = 59386 \pm 20$ Mc/s; $\lambda_1 = [Rd\lambda/dR]_e = 16896 \pm 150$ Mc/s; $\lambda_2 = [(R^2/2)(d^2\lambda/dR^2)]_e = (5 \pm 2) \times 10^4$ Mc/s; $\lambda_{\text{eff}}(v=0) = 19501.57 \pm 0.15$ Mc/s. The transformation that diagonalizes the Hamiltonian is given with respect to both Hund case (a) and case (b) bases. These transformations are applied to matrix elements of S_Z . The results are tabulated and applied to calculate the exact intensity factors for spectral lines. This calculation shows slight deviations from the usual case (b) results for allowed lines and predicts quite sizeable intensities for the "forbidden" $\Delta K = 2$ lines.

A.

539.132 : 541.124

3937. Singlet-triplet excitation energy of aromatic compounds and their reactivities. M. SZWARC. Letter in *J. chem. Phys.*, **23**, No. 1, 204-6 (Jan., 1955).

The addition reaction of a radical R with an aromatic compound A is regarded as the change from the repulsive system $R + {}^1A$ to the attractive system $R + {}^3A$. Then for different A reacting with the same R , the activation energies should be proportional to the singlet-triplet excitation energies of A . Plotting log (methyl affinity) [see Abstr. 582 (1955)] against $S-T$ splitting for various aromatic compounds of different types, a reasonable straight line is obtained, supporting this model of the reaction.

J. HAWGOOD

539.132

3938. Cl^{35} pure quadrupole resonances in substituted chlorobenzene. P. J. BRAY. Letter in *J. chem. Phys.*, **23**, No. 1, 220-1 (Jan., 1955).

539.132

3939. Quadrupole interaction of Cd^{111} . P. LEHMANN AND J. MILLER. *C.R. Acad. Sci. [Paris]* **240**, No. 3, 298-9 (Jan. 17, 1955) In French.

Cd^{111} emits two successive γ -rays and the directional anisotropy between the two emissions is an oscillating function of the time interval between them. Experiment is in agreement with the theory of Abragam and Pound [Abstr. 2727 (1954)] and the quadrupole coupling of the intermediate nucleus of mean life 8×10^{-8} sec is about 200 Mc/s in CdSO_4 crystals.

D. H. WHIFFEN

539.132

3940. Nuclear quadrupole resonances of As^{75} . R. G. BARNES AND P. J. BRAY. Letter in *J. chem. Phys.*, **23**, No. 2, 407 (Feb., 1955).

Resonance frequencies are given for As^{75} in AsCl_3 , AsBr_3 , AsI_3 , $\text{As}(\text{C}_2\text{H}_5)_3$, for Br^{81} in AsBr_3 and for Sb^{121} and Sb^{123} in SbCl_3 .

D. H. WHIFFEN

539.132

3941. Magnetic hyperfine effects and electronic structure of NO. G. C. DOUSMANIS. *Phys. Rev.*, **97**, No. 4, 967-70 (Feb. 15, 1955).

The theory of magnetic hyperfine structure in diatomic molecules is briefly re-examined. Previously reported hyperfine effects in the $\text{N}^{14}\text{O}^{16}$ molecule, both magnetic and electric quadrupole, are interpreted with corrected theoretical expressions in terms of an electronic structure consisting of 65% $\text{N}=\text{O}$ and 35% $\text{N}^+=\text{O}^+$. The unpaired electron is shown to be essentially in a $2p$ π -orbital but with 2.5% s character. Discrepancies of about 8% between experimental and calculated values of the magnetic hyperfine constants indicate limitations in the use of atomic wave-function approximations for electronic orbitals.

A.

539.132 : 541.632

3942. Evidence for the interconversion of monochloroacetic acid by its pure quadrupole spectrum. H. NEGITA. Letter in *J. chem. Phys.*, **23**, No. 1, 214-15 (Jan., 1955).

Evidence is obtained from the pure quadrupole resonances near 35 Mc/s for the existence and interconversion of *gauche*- and *trans*-forms of CH_2ClCOOH dimer in the solid state.

D. H. WHIFFEN

539.132

3943. The electrical polarizability of conjugated molecules: the use of free-electron orbitals. H. C. BOLTON. *Trans Faraday Soc.*, **50**, Pt 12, 1265-9 (Dec., 1954).

It is shown that free-electron orbitals are quite satisfactory for calculations of the π -polarizability of long-chain conjugated molecules and give results in close agreement with those of Davies who used LCAO molecular orbitals. To interpret the results correctly it has been necessary to examine more carefully the relationship between the two conventional expressions derived from a perturbed many-electron wave-function set up (i) in terms of eigenfunctions, and (ii) in terms of a variational parameter. In the light of the success of the free-electron approximation in the linear case, it is applied to benzene and the value of the π -electron transverse polarizability is shown to be about one-half that of the ring.

A.

539.132

3944. Molecular calculations. III. A modification of the naive semiempirical MO method. L. GOODMAN AND H. SHULL. *J. chem. Phys.*, **23**, No. 1, 33-44 (Jan., 1955).

It is shown how the conventional naive semiempirical molecular orbital approach for conjugated hydrocarbons may be complemented by means of theoretically computed electron repulsion integrals in a manner suggested by the more rigorously founded SCF procedure. This is shown to give satisfying results in three examples with a considerable reduction in labour as compared to the complete ASMO method. The method is carried over in a natural and simple manner to substituted hydrocarbons, providing unambiguous methods of evaluating empirical resonance and inductive parameters. The concept of "weak" and "strong" substituent is developed and it is shown how these provide simple intuitive approaches

to the estimation of interaction parameters in the theory. The inductive and resonance effects upon the energy levels are shown to be far from additive, and indeed are dependent upon each other. The dependence is analysed and it is indicated which ones are important (and determinable) from various experimental situations. A.

539.132

3945. On the separation of inductive and mesomeric effects by molecular orbital theory. H. H. JAFFÉ. *J. Amer. Chem. Soc.*, **77**, No. 2, 274–80 (Jan. 20, 1955).

Calculations of electron densities and localization energies by perturbation theory applied to the semi-empirical LCAO molecular orbital method are analysed into four separate steps. The individual steps are used to separate the various effects used by the English school in the qualitative interpretation of the reactivity of conjugated organic compounds. A.

539.132

3946. Theoretical study of the ozone molecule. I. FISCHER-HJALMARS. Letter in *J. chem. Phys.*, **23**, No. 2, 411 (Feb., 1955).

Theoretical. Describes a self-consistent LCAO MO calculation for four *A*₁ configurations of O₃, using 2*p* orbitals, both of Slater and Hartree-Fock types. The levels obtained are very close, so that configuration interaction is not negligible. The order of each bond to the central O is slightly greater than that of a single bond; the outer O atoms repel each other. The sign of the dipole moment is wrongly predicted. Preliminary calculations including 2*s* orbitals agree better with experiment. J. HAWGOOD

539.132

3947. Applications of the alternant molecular orbital method to six- and four-electron systems. H. YOSHIZUMI AND T. ITOH. Letter in *J. chem. Phys.*, **23**, No. 2, 412–13 (Feb., 1955).

Theoretical. The method takes correlation between electrons with antiparallel spins into account by constructing (by LCAO) MOs in which there are maxima on alternate atoms for α - and for β -spin. Application to benzene and acetylene, with one parameter, gives energy depressions amounting to 85% and 70% of those given by long configuration interaction calculations. J. HAWGOOD

539.132

3948. Application of the alternant orbital method to benzene. T. ITOH AND H. YOSHIZUMI. *J. Phys. Soc. Japan*, **10**, No. 3, 201–7 (March, 1955).

An improvement on the molecular orbital method is made by taking into account the correlation between the motions of electrons with opposite spin. For this purpose electrons with plus spin are assigned to orbitals which are somewhat localized at alternate atoms in molecules, while electrons with minus spin are assigned to orbitals localized at the remaining atoms. With the use of the alternant orbitals a wave-function with a given multiplicity and spatial symmetry can be constructed. The method is applied to the π -electron system of the ground state of benzene and the results are compared with those obtained by the method of configuration interaction (C.I.). The energy depression obtained by the present method is 2.35 eV while that by C.I. is 2.7 eV. The inner

product of these two wave-functions is 0.985, which shows that the present method is a very satisfactory approximation to the C.I. calculation. A.

539.132

3949. On the method of atoms in molecules. A. C. HURLEY. *Proc. Phys. Soc. [London]* **A**, **68**, Pt 3, 149–55 (March, 1955).

The method is investigated in detail for the case of covalent-ionic resonance in the ground state of the hydrogen molecule. It is shown that the method is reliable if, and only if, different orbitals are used to approximate atomic and ionic states of the same molecule. A.

539.132 : 541.5

3950. Divalent hydrogen in the FHF⁻ ion. R. T. SANDERSON. Letter in *J. chem. Phys.*, **23**, No. 1, 217 (Jan., 1955).

Discussion of charge distribution and electro-negativities in the linear symmetrical FHF⁻ ion, and in various hypothetical syntheses of it, indicates that the H may be regarded as divalent, the bond being unlike the usual H bond. Estimated charges are -0.044 on H and -0.478 on each F. J. HAWGOOD

539.132 : 541.57

3951. The theoretical values of the polarizabilities of carbon-carbon bonds. H. C. BOLTON. *Trans Faraday Soc.*, **50**, Pt 12, 1261–4 (Dec., 1954).

Theoretical values are presented of the polarizability tensors for the C–C, C=C and C $\equiv$ C bonds. The theory employed the Kirkwood approximation which needs only the ground-state wave-function. This wave-function, in each case, was constructed from an antisymmetric product of molecular orbitals, treating each bond as a separate diatomic system. In this way, the extraordinarily large anisotropy of the C–C bond given from experimental data by Wang and Denbigh is shown to be unreasonable but the theory is in satisfactory agreement with the revised values of Bunn and Daubeney. For the C=C and C $\equiv$ C bonds, the empirical and theoretical values of the anisotropies are in complete agreement. A.

539.133 : 535.343

Orientation in molecular complexes. See Abstr. 3588

539.133

3952. The dipole moment and relaxation times of acetic anhydride and the rotation of its acetyl groups. B. EKELUND. *Åbo: Åbo Akademi* (1954) 93 pp. [*Acta Academiae Aboensis, Math. Phys.* XIX, 11].

From measurements at 22 cm wavelength the dipole moment of acetic anhydride is found to be 3.12–3.15 D and the apparent relaxation times for the long wavelength side of the dispersion region in units of 10⁻¹² sec are found to be 22 in pentane, 25 in hexane, 31 in benzene and ~49 in dioxane solutions. The numerical values are shown to indicate free rotation of the acetyl groups.

D. H. WHIFFEN

539.133 : 538.222

3953. Interaction of molecular oxygen with a magnetic field. M. TINKHAM AND M. W. P. STRANDBERG. *Phys. Rev.*, **97**, No. 4, 951–66 (Feb. 15, 1955).

The dominant interaction of O₂ with a magnetic field is through the electronic spin magnetic moment.

However, a precise comparison with experiment of the results of calculating the microwave paramagnetic spectrum, assuming only this interaction, shows a systematic discrepancy. This discrepancy is removed by introducing two corrections. The larger (approximately 0.1%, or 7 gauss.) is a correction for the second-order electronic orbital moment coupled in by the spin-orbit energy. Its magnitude is proportional to the second-order term μ'' in the spin-rotation coupling constant. The smaller (approximately 1 gauss.) is a correction for the rotation-induced magnetic moment of the molecule. Since the dependence of this contribution on quantum numbers is quite unique, this coefficient can also be determined by fitting the magnetic spectrum. A total of 120 X -band and 78 S -band lines were observed. The complete corrections have been made on 26 lines with a mean residual error of roughly 0.5 Mc/s. This excellent agreement confirms the anomalous electronic moment to 60 parts per million (ppm) and also confirms the validity of the Zeeman-effect theory. A new result is the rotational magnetic moment of -0.25 ± 0.05 nuclear magnetons per quantum of rotation. Knowledge of this moment allows the electronic contribution to the effective moment of inertia to be determined. Making this correction of 65 ppm, and using the latest fitting of the universal atomic constants, the equilibrium internuclear distance is recomputed to be $R_e = 1.20741 \pm 0.00002$ Å. It can also be deduced that the magnitude of λ'' , the second-order spin-orbit contribution to the coupling of the spin to the figure axis, is 465 ± 50 Mc/s, or less than 1% of the total coupling constant, λ . Theoretical intensities of a number of the microwave transitions are calculated and successfully compared with experiment over a range of 100 to 1 in magnitude. It turns out that $\Delta M = 0$ transitions are over a hundred times weaker than the $\Delta M = \pm 1$ transitions and thus are weak to observe. Also, J breaks down as a quantum number in the presence of a magnetic field. This allows $\Delta J = \pm 2$ transitions to comprise roughly half of all lines observed.

A.

539.133

3954. Symmetry of the local crystalline field about rare earth ions in octahydrated sulfate crystals. R. A. SATTEN AND D. J. YOUNG. Letter in *J. chem. Phys.*, **23**, No. 2, 404-5 (Feb., 1955).

Previous experimental evidence on octahydrated rare-earth sulphate crystals is conflicting with respect to the local symmetry about the rare-earth ion: paramagnetic susceptibility measurements showed it to be non-cubic, whilst specific heat measurements indicated a cubic field; this was also found on the basis of spectral data, as the $^4I_{9/2}$ ionic ground state was split into three levels. Here the absorption spectrum of $\text{Nd}_2(\text{SO}_4)_3 \cdot 8\text{H}_2\text{O}$ crystals was investigated and the $^4I_{9/2}$ state found to be split up into five levels. The level schemes for higher states were calculated and complete agreement was obtained with experiments. The separations reported show a slight departure from cubic symmetry. It is shown which groups of symmetry are possible in such rare-earth compounds.

A. J. TAYLOR

539.133

3955. Carbon-carbon and carbon-hydrogen distances

in simple polyatomic molecules. G. HERZBERG AND B. P. STOICHEFF. Letter in *Nature [London]* **175**, 79-80 (Jan. 8, 1955).

In compounds where a single C—C bond is adjacent to a triple bond, whether $\text{C}\equiv\text{C}$ or $\text{C}\equiv\text{N}$, the single bond is always close to 1.460 Å, whilst it is near to 1.544 Å when the adjacent bonds are single. When the single bond lies between two triple bonds, the distance is close to 1.380 Å. In compounds with two adjacent double bonds the C=C distance is about 1.309 Å, which is much smaller than that in ethylene. The triple bond distance (1.207 Å) does not depend greatly on adjacent groups. The C—H distance depends on the environment, but not as strongly as the C—C distance. In all cases the effect of the adjacent type of bond is larger than the effect of the adjacent atom.

A. J. TAYLOR

ATOMS . NUCLEUS . ISOTOPES 539.15

539.152.1

3956. On the foundation of the collective model of the nucleus. H. A. TOLHOEK. *Physica*, **21**, No. 1, 1-21 (Jan., 1955).

An analysis is given of a number of assumptions underlying the collective model of the nucleus of A. Bohr. The connection between properties of the nucleus expressed in terms of collective co-ordinates in terms of individual nucleon co-ordinates is studied. This is done both for the Hamiltonian and for the expressions for the magnetic moment, the quadrupole moment and matrix elements for nuclear transitions. A variational principle is used in order to derive the connection between the Bohr Hamiltonian for the motion of the surface of the core (and the extra nucleons) and the Hamiltonian expressed as an operator acting on the co-ordinates of the individual nucleons.

A.

539.152.1

3957. Two-body forces and nuclear saturation. III. Details of the structure of the nucleus. K. A. BRUECKNER. *Phys. Rev.*, **97**, No. 5, 1353-66 (March 1, 1955).

For Pt I, see Abstr. 69 (1955). The characteristics of particle motion in the nuclear medium have been examined in detail. The origin of the strong dependence of the potential energy on the nucleon momentum is discussed and an equivalent formulation is exhibited in which a uniform and constant potential is assumed but the nucleon moves with markedly reduced mass. The determination of the potential is shown to lead to a self-consistency problem which is to some extent similar to that appearing in the Hartree method of self-consistent fields. Solution of this problem shows that the self-consistency requirements impose severe restrictions on the solution and have a strong stabilizing influence in the saturation problem. The volume energy of the nucleus has been evaluated by using two-body potentials closely equivalent to a combination of central and tensor forces which agree with the low-energy parameters and predict scattering correctly up to 90 MeV. The result agrees closely with the observed values of

energy and density. The collective character of the nucleon potential is described and shown to manifest itself markedly in the excitation energy of single-particle levels where a considerable fraction of the energy is taken up in small adiabatic shifts of the states of the remaining nucleons. The origin of the surface and symmetry energy is discussed; an evaluation of these effects gives a result in good agreement with empirically derived values. The stability of the nucleus against distortion arising from the polarizing effects of the tensor force is also examined and it is found that the nucleus shows marked stability against such distortion.

A.

539.152.1

3958. Theory of nuclear models. R. J. EDEN AND N. C. FRANCIS. *Phys. Rev.*, **97**, No. 5, 1366–79 (March 1, 1955).

The framework for a unified theory of nuclear structure is described in which the wave-functions for different nuclear models are obtained by transformations on the actual nuclear wave-function. This formulation provides a basis for explaining the success of weak-coupling models of the nucleus and showing that they are not in conflict with the assumption that nucleons have very strong mutual interactions. The explanation lies in the fact that only in certain circumstances can the “particles” in a nuclear model be interpreted as nucleons. The properties which transformation operators must have to change the nuclear wave-function into a model wave-function are investigated and the extent to which these properties are satisfied in practice is considered. Self-consistent equations are set up for a model having a product wave-function in the particle variables, and it is shown that these equations can be solved in an approximation relevant to the problem of nuclear saturation.

A.

539.152.1

3959. Orbital angular momentum distribution in nuclei and nuclear density. L.-M. YANG. *Acta Sci. Sinica*, **3**, No. 2, 153–64 (June, 1954).

From the Thomas–Fermi model, one can obtain a continuous statistical angular momentum distribution $n(l)$, depending only on the nuclear density ρ . A density distribution function $\rho(r) = \rho^0$, $r < R_0 = \rho^0 e^{-(r-R_0)^2/a^2}$, for $r > R_0$, is chosen. In this case, $n(l)$ is a function only of $\beta^2 = R_0^2/3a^2$. Comparison with the empirical curve gives β as a function of A . Assuming a nuclear radius parameter $r_0 = 1.4 \times 10^{-13}$ cm, a is found to be about 2.5×10^{-13} cm.

In an appendix, a suggestion of two types of shell structure is considered.

G. E. BROWN

539.152.1

3960. Structure of phase space and a relation between angular momentum and density distribution of nucleons in the nucleus. W. R. THEIS. *Z. Phys.*, **140**, No. 1, 1–15 (1955) In German.

An unambiguous relationship between the number of particles possessing a given l , and the continuous function $N(L^2)$ obtained from the statistical model is established. This depends only on the degeneracy of the eigenvalues. The function $N(L^2)$ is expressed in terms of the particle density. Good agreement between occupation numbers predicted by $N(L^2)$ and

the known number of particles possessing a given l is obtained for the atomic electrons and it is shown that a uniform nuclear distribution reproduces well the known nuclear angular momentum occupation numbers.

G. E. BROWN

539.152.1

3961. Studies in intermediate coupling. III. The lithium isotopes. A. M. LANE. *Proc. Phys. Soc. [London] A*, **68**, Pt 3, 189–96 (March, 1955).

The methods of Pt II [Abstr. 3752 (1954)] are applied to the analysis of the reaction data on the lithium isotopes in terms of an intermediate coupling shell model of the nucleus. It is found that, to within the expected uncertainties, all of twelve data are consistent with the predictions of the model. The mean value of the intermediate coupling parameter a/K is about 3. As an incidental result, it is found that the β -decay data cannot be fitted with the old interaction mixture based on mirror transitions, but requires a new mixture based on mirror transitions, but requires a new mixture based on the O^{14} Fermi transition.

A.

539.152.1

3962. Studies in intermediate coupling. IV. Further remarks on the nuclei ^{13}C and ^{13}N . A. M. LANE. *Proc. Phys. Soc. [London] A*, **68**, Pt 3, 197–203 (March, 1955).

The results reported in Pt I and II on the nuclei C^{13} and N^{13} are extended in three ways: (i) The β -decay ft -value for the allowed mirror transition has been examined in intermediate coupling and is shown to be in excellent agreement with the previous results. (ii) Some properties of the nuclei have been recalculated with different assumptions about the central force between nucleons. It is found that the previous results are not very much changed, even when the central force mixture is quite severely modified. (iii) Some discussion is given about the even parity states of C^{13} and N^{13} . In particular the application of the “unique parent” concept to these states, and its justification, is considered.

A.

539.152.1

3963. Level scheme of In^{115} . J. VARMA AND C. E. MANDEVILLE. *Phys. Rev.*, **97**, No. 4, 977–84 (Feb. 15, 1955).

The disintegration of the 2.3 day Cd^{115} and its isomer, the 43 day Cd^{115} , have been studied with thallium-activated sodium iodide counters, anthracene counters and coincidence methods. The levels of In^{115} have been shown to have excitation energies of 0.335 ($T_{1/2} = 4.5$ hr), 0.595, 0.825, 0.858, 0.935, 1.30 and 1.42 MeV, the first four levels being excited in the decay of the 2.3 day period alone and the latter three in decay of the 43 day activity only. The γ -transitions from the 1.3 MeV level proceed directly to the ground state of In^{115} while all the transitions from the 1.42 MeV level terminate at the 0.935 MeV level. The γ -transitions from the 0.595, 0.825 and 0.858 MeV levels lead to the metastable state at 0.335 MeV. About 3% of the transitions from the 0.858 MeV level terminate at the 0.825 MeV level which in turn de-excites by way of a 0.230 MeV–0.260 MeV γ -ray cascade or by emission of a 0.490 MeV quantum in the crossover transition. The angular correlation function for the 0.485 MeV–0.935 MeV cascade in the decay of

the 43 day Cd^{115} is found to be essentially isotropic. A level scheme for In^{115} has been established by these measurements.

A.

539.152.1

3964. Direct evaluation of fractional parentage coefficients using Young operators. General theory and $\langle 4/2, 2 \rangle$ coefficients. H. A. JAHN. *Phys. Rev.*, **96**, No. 4, 989–95 (Nov. 15, 1954).

General expressions for $\langle n/m, n-m \rangle$ fractional parentage coefficients are derived, for the special case where the state vectors are all different, by using normalized Young symmetry operators constructed out of permutation operators acting on the state vectors. The coefficients are given directly in terms of matrix elements of the permutations characterizing the cosets of the subgroup $S_m \times S_{n-m}$ of S_n multiplied by the corresponding permutation operator. The permutation operators themselves are expressible in terms of Racah W functions. Explicit expressions for the $\langle 4/2, 2 \rangle$ coefficients are given also for cases where some of the state vectors are identical.

A.

539.152.1

3965. Definition of the virtual level of the deuteron. J. HUMBLET. *Phys. Rev.*, **97**, No. 4, 1145 (Feb. 15, 1955).

As a supplement to Ma's review article on the subject [Abstr. 4826 (1954)], the most frequently suggested definitions are discussed on the basis that nearly equal potentials should have nearly equal virtual (and resonance) levels. This point of view is in opposition to the most usual definition $\phi'(r_0, k) = 0$ and favours the Siegert (or S -matrix) definition $\phi'(r_0, k) - ik\phi(r_0, k) = 0$.

A.

539.152.1

3966. The contribution of non-static forces to the binding-energy of the deuteron. F. CERULUS. *Helv. phys. Acta*, **28**, No. 1, 67–84 (1955).

The Bethe-Salpeter equation for the bound states of a neutron and a proton, having a scalar interaction with a charged meson-field, is set up. Keeping the binding energy fixed the eigenvalue for the coupling constant g is determined, taking into account the g^2 and the g^4 terms in the equation. This is done by means of a perturbation method, starting from the static approximation, and showing that the non-static forces contribute an important part to the binding. For a 2.18 MeV binding energy there results $g^2 = 0.54 g_0^2$ where g_0 is the value obtained from the static approximation.

A.

539.152.1

3967. On the excited states of even-even nuclei. M. NAGASAKI AND T. TAMURA. Letter in *Progr. theor. Phys.*, **12**, No. 2, 248–50 (Aug.); Erratum, No. 4, 551 (Oct., 1954).

Comments on energy ratios in some 25 level sequences of the type $0^+ - 2^+ - 4^+$ and $0^+ - 2^+ - 2^+$ in view of their interpretation as rotational or shell model levels.

W. J. SWIATECKI

539.152.1

3968. Correspondence between semiclassical and quantum treatments of Coulomb excitation. G. BREIT AND P. B. DAITCH. Letter in *Phys. Rev.*, **26**, No. 5, 1447–8 (Dec. 1, 1954).

Correspondence implies a particular equality, which

is given here. Qualitative arguments for the fulfilment of this equality can be made with the JWKB approximation.

G. E. BROWN

539.152.1

3969. Validity of semiclassical treatment of Coulomb excitation. P. B. DAITCH, J. P. LAZARUS, M. H. HULL, JR., F. D. BENEDICT AND G. BREIT. Letter in *Phys. Rev.*, **96**, No. 5, 1449–50 (Dec. 1, 1954).

The quantum and semiclassical expressions are evaluated numerically for various values of the angular momenta and compared.

G. E. BROWN

539.152.2

3970. Spin, magnetic moment, and hyperfine structure of Rb^{81} . J. P. HOBSON, J. C. HUBBS, W. A. NIERENBERG AND H. B. SILSBEE. Letter in *Phys. Rev.*, **96**, No. 5, 1450 (Dec. 1, 1954).

The zero moment method of atomic beams when applied to Rb^{81} (4.7 hr) gives the spin as $3/2$, the hyperfine splitting as $5\,000 \pm 125$ Mc/s and the nuclear moment as 2.00 ± 0.06 n.m.

D. H. WHIFFEN

539.152.2

3971. Evaluation of the nuclear quadrupole moment of N^{14} . A. BASSOMPIERRE. *C.R. Acad. Sci. [Paris]* **240**, No. 3, 285–7 (Jan. 17, 1955) In French.

From a knowledge of the atomic quadrupole field obtained from self-consistent wave-functions for the HCN molecule [Abstr. 2058 (1955)] and of the experimental quadrupole coupling of N^{14} in the HCN molecule, a value of the nuclear quadrupole moment ($Q = 0.00071 \times 10^{-24} \text{ cm}^2$) is found.

G. E. BROWN

539.152.2

3972. Alignment of ^{56}Co nuclei. I. Experimental results: determination of magnetic moment. L. J. GALLAHER, C. WHITTLE, J. A. BEUN, A. N. DIDDENS, C. J. GORTER AND M. J. STEENLAND. *Physica*, **21**, No. 2, 117–23 (Feb., 1955).

A dilute copper ammonium Tutton salt, containing a small amount of Co^{56} , was cooled by adiabatic demagnetization to about 0.02°K and an anisotropy in the angular distribution of the γ -intensity, resulting from the nuclear alignment, was found in each of the six γ -rays. An estimate of the magnetic moment of Co^{56} yielded 2.8 ± 0.9 nuclear magnetons.

A.

539.152.2

3973. Alignment of cerium-141 and neodymium-147 nuclei. E. AMBLER, R. P. HUDSON AND G. M. TEMMER. *Phys. Rev.*, **97**, No. 5, 1212–21 (March 1, 1955).

The radioactive nuclei Ce^{141} and Nd^{147} have been aligned by the magnetic h.f.s. method (Bleaney) using single crystals of cerium magnesium nitrate. The cerium site is characterized by $B \gg A$, i.e. the "alignment" occurs in a plane. The anisotropies for the 142 keV γ -ray of Ce^{141} , and the 92 keV and 530 keV γ -rays of Nd^{147} , at the lowest temperature (0.00308°K) were found to be $+0.12$, 0 and -0.39 , respectively. These values coupled with the rate of change of anisotropy with temperature identify the transitions as $M1$, $M1 + E2$ and $E2$, respectively. The decay schemes supported by these experiments are as follows: Ce^{141} (142 keV), $7/2^- \xrightarrow{0} 7/2^+ \xrightarrow{1} 5/2^+$; Nd^{147} (92 keV), $9/2^- \xrightarrow{1} 7/2^+ \xrightarrow{1.2} 5/2^+$; Nd^{147}

(530 keV), $9/2^- \xrightarrow{0} 9/2^+ \xrightarrow{-2} 5/2^+$. From the temperature dependence of the anisotropies values for the magnetic moments can be deduced as follows: Ce^{141} , 0.16 ± 0.06 n.m.; Nd^{147} , 0.22 ± 0.05 n.m. These rather small values for odd-neutron nuclei may not be meaningful because of possible internal magnetic field effects in the crystal which are not taken into account in the treatment of the hyperfine interaction. A.

539.152.2

3974. Gyromagnetic ratio of an excited state and other angular correlation measurements for Pb^{204m} . V. E. KROHN AND S. RABOY. *Phys. Rev.*, **97**, No. 4, 1017–22 (Feb. 15, 1955).

The spin assignment, $9-4-2-0$, for the levels of the triple cascade of Pb^{204m} has been found consistent with angular correlation measurements provided the first and second γ -rays are multipole mixtures. The first γ -ray must be $E5$ with a 1% mixture of $M6$, and the second γ -ray must be $E2$ with 0.5% $M3$. The gyromagnetic ratio of the 2.6×10^{-7} sec state was measured by angular correlation techniques, and the result, $g = +0.054 \pm 0.005$ nuclear units, was obtained. If one assumes the validity of the spin 4 assignment for this state, the magnetic moment is 0.22 ± 0.02 nuclear magnetons. An attempt to observe time-dependent attenuation of the angular correlation in an HNO_3 medium gave an upper limit of 10% attenuation with variation of the delay time from 1.85×10^{-7} to 5.5×10^{-7} sec. A.

539.152.2

3975. Magnetic moments of conjugate nuclei. J. G. BRENNAN AND A. B. VOLKOV. *Phys. Rev.*, **97**, No. 5, 1380–6 (March 1, 1955).

Many experimentally-observed magnetic moments of conjugate (semi-mirror) nuclei deviate approximately the same amount from the Schmidt limits. It is shown that the theoretical magnetic moments provided by a simple form of the collective model are such that the difference between the deviations of a pair of conjugate nuclei is small. Those experimentally-observed exceptions to this rule where the difference between the deviations is quite large (such as $\text{I}^{127}\text{—Mo}^{97}$) can be explained by modifications of the collective model to include the effects of (a) shell model structure, and (b) configuration admixing. In fact, the relative importance of the various dynamical features of the nucleus can be assessed, qualitatively at least, from the size and sign of the magnetic moment deviation difference of a pair of conjugate nuclei. A.

539.152.2

3976. On further echoes with the Hahn spin-echo method. H. PFEIFER, U. DOLEGA AND H. WINKLER. *Ann. Phys. [Leipzig]* **15**, No. 3–4, 246–8 (1955) In German.

It is shown that the Hahn spin-echo determination [Abstr. 2922 (1951)] of the transverse relaxation time, T_2 , is only valid if the time between pairs of impulses, θ , is long compared to the longitudinal relaxation time, T_1 . Otherwise an echo at $\theta + 3\tau$ (τ = time between the impulses in one pair) may be observed and its amplitude contains a factor $\exp(-\theta/T_1)$. Variation of echo pattern with θ will give an indication of T_1 . D. H. WHIFFEN

539.152.2

3977. Spin-echo memory device. S. FERNBACH AND W. G. PROCTOR. *J. appl. Phys.*, **26**, No. 2, 170–81 (Feb., 1955).

A proton-rich sample placed in a strong inhomogeneous magnetic field of mean strength H_0 was subjected to a pattern of relatively weak radiofrequency pulses at the Larmor frequency of the protons in the field H_0 . The pattern was then recalled by applying a strong r.f. pulse at a later time as in the spin-echo technique. It is shown both mathematically and experimentally that such a series of pulses, varying in amplitude, can be “memorized” by the spin system of protons for times as long as one second and then repeated, preserving both shape and relative amplitude. A.

539.152.2

3978. Effects of perturbing radiofrequency fields on nuclear spin coupling. A. L. BLOOM AND J. N. SHOOLERY. *Phys. Rev.*, **97**, No. 5, 1261–5 (March 1, 1955).

An analysis is made of double resonance experiments in which the $I_1 \cdot I_2$ interaction observable in certain nuclear magnetic resonance spectra is perturbed by a strong radiofrequency field. The problem is treated by transforming to a rotating co-ordinate system in which all terms in the Hamiltonian are stationary except for the weak r.f. field used to investigate the spectrum. Transition energies and intensities are computed in the rotating frame and the spectrum transformed back to the laboratory frame by adding a constant factor to the energy. A double-resonance experiment involving the nuclei F^{19} and P^{31} is described and the experimental results compared with those computed from the theory. A.

539.152.2 : 536.7

3979. Thermodynamics of the relaxation in nuclear resonance. F. LURÇAT. *C.R. Acad. Sci. [Paris]* **240**, No. 2, 166–8 (Jan. 10, 1955) In French.

539.153

3980. Second-order radiative corrections to the magnetic moment of a bound electron. E. H. LIEB. *Phil. Mag.*, **46**, 311–16 (March, 1955).

Radiative corrections to the magnetic moment of an outer electron in alkali and hydrogenic atoms due to the atomic electrostatic field have been calculated to second order. The correction is found to be

$$\frac{\Delta\mu}{\mu} = \frac{26}{15\pi^2} \frac{\langle V \rangle}{mc^2}$$

where $\langle V \rangle$ is the expectation value of the electron's potential energy. For hydrogen this is $\Delta\mu/\mu = 2.2 \times 10^{-7} \simeq -(2/\pi)\alpha^3$ and will be of importance in the evaluation of future experiments of improved accuracy. For the alkalis, however, the effect is too small to account for the observed Z -dependence of the magnetic moment. A.

539.153 : 537.531

3981. Energies of the K transitions of π^- mesonic X-rays. M. STEARNS, M. B. STEARNS, S. DEBENEDETTI AND L. LEIPUNER. *Letter in Phys. Rev.*, **97**, No. 1, 240–2 (Jan. 1, 1955).

By pulse-height measurements the energies of $2p\text{—}1s$ π -mesonic X-rays were determined for C, N,

O, F [see Abstr. 545, 2087 (1955)]. Comparison with energies calculated without taking into account nuclear interactions shows shifts up to 14% for F, which agree with the work of Deser *et al.* [Abstr. 1126 (1955)].

W. J. SWIATECKI

539.153.4

3982. An absorber model of hydrogen atoms. K. JUST. *Z. Phys.*, **140**, No. 1, 16–35 (1955) In German.

Following the quantum electrodynamics of Ludwig [Abstr. 4086 (1951), 6279 (1952)] based on the classical action-at-a-distance theory of Wheeler and Feynman [Abstr. 733 (1946), 3752 (1950)], an absorber with a continuous spectrum of energy states must be considered to yield virtual intermediate states and an electromagnetic self-mass. This absorber is considered as made up of hydrogen atoms. Renormalization of mass is carried through and Bethe's approximate formula for the Lamb shift is obtained.

G. E. BROWN

539.153.4

3983. On an approximation to the Fermi distribution function. T. TIETZ. *Ann. Phys. [Leipzig]* **15**, No. 3–4, 186–8 (1955) In German.

The distribution function y is approximated over the entire range of x by $y = a^2/(x + a)^2$. Numerical values agree roughly with the exact solution.

G. E. BROWN

539.153.4

3984. The "boundary effect" in the Thomas–Fermi model for atoms. R. A. BALLINGER AND N. H. MARCH. Letter in *Phil. Mag.*, **46**, 246–7 (Feb., 1955).

By considering the asymptotic relation for the total energy $E(Z)$ of Z particles in a potential Z/r an expression is deduced for the total ionization energy of an actual atom, correct to order $Z^{2/3}$ and in even better agreement with observation than Scott's formula (1952).

W. J. SWIATECKI

539.153.4

3985. On the validity of the Weizsäcker inhomogeneity correction term. R. BERG AND L. WILETS. *Proc. Phys. Soc. [London]* **A**, **68**, Pt 3, 229–39 (March, 1955).

An investigation is made of Weizsäcker's correction to the Thomas–Fermi statistical treatment of the many-body problem. Numerical solutions of Weizsäcker's equation were obtained for the isotropic harmonic oscillator and the step potential in plane symmetry. These particular potentials were chosen as approximations to nuclear potentials. In the case of the harmonic oscillator, the error in the energy is an order of magnitude greater than for the Thomas–Fermi equation, but a reduction in the magnitude of the Weizsäcker correction term by a factor of $\frac{1}{2}$ gives substantial improvement over the Thomas–Fermi solution. The step potential also shows that the Weizsäcker term is too great, but the reduction factor necessary to give substantial improvement is between $\frac{1}{2}$ and 1. It is concluded that the Weizsäcker correction term is not reliable as such, but that a reduction in the magnitude of the term may give plausible solutions for the density. The reduction factor depends, however, upon the form of the potential.

A.

Generalization of Feynman's theory of energy levels of liquid helium. See Abstr. 3692

539.153.4 : 536.48

539.155.2

3986. Evidence for a second naturally occurring isotope in tantalum. J. E. EVANS, E. G. JOKI AND R. R. SMITH. Letter in *Phys. Rev.*, **97**, No. 2, 565–6 (Jan. 15, 1955).

A small "resonance-shaped" peak was observed during high-resolution tantalum total neutron cross-section measurements with the Materials Testing Reactor crystal spectrometer, and attributed to a hitherto undiscovered naturally occurring rare isotope of Ta. Using the mass-spectrometric data of White *et al.* (abstract following) (Ta^{180} , relative abundance $123 \pm 3 \times 10^{-6}$) the level parameters are $E_0 = 0.433 \pm 0.004$ eV, $\sigma_0 = 12900 \pm 1000$ barn, $\Gamma = 0.030 \pm 0.005$ eV, and $g\Gamma_n = 0.6 \times 10^{-4}$ eV. The isotope is probably radioactive.

A. O. STANESBY

539.155.2

3987. New naturally occurring isotope of tantalum. F. A. WHITE, T. L. COLLINS, JR, AND F. M. ROURKE. Letter in *Phys. Rev.*, **97**, No. 2, 566–7 (Jan. 15, 1955).

See also preceding abstract. The mass-spectrum of Ta was examined using a 2-stage magnetic analyser with two 90° 12 in.-radius-of-curvature sectors in tandem. The abundances obtained were: 180, 0.0123 ± 0.0003 ; 181, 99.988; 177, 178, 179 < 0.0003 (not observed); and 182, 183 < 0.0002% (not observed).

A. O. STANESBY

539.155.2

3988. The enrichment of radio-active isotopes by thermal diffusion. A. E. DE VRIES. *Physica*, **21**, No. 2, 124–6 (Feb., 1955).

The method, using thermal-diffusion column, is of importance when the quantity which has to be enriched is small compared to the hold-up of the column. In this case a longer column would not give a better enrichment. As an example CO is chosen in which the $C^{14}O$ has to be concentrated in a small amount of $C^{12}O$.

A.

539.155.4

3989. Masses of light nuclei. J. E. DRUMMOND. *Phys. Rev.*, **97**, No. 4, 1004–7 (Feb. 15, 1955).

Values for the atomic masses of 42 nuclei from n^1 to S^{34} are derived from data on 110 nuclear reactions and mass spectrographic doublets. A variance-covariance matrix for the results is also derived and a further 32 masses in the same region are included. These results are found to be consistent with most of the data available.

A.

RADIOACTIVITY . α -, β - AND γ -RAYS 539.16

539.16.08

3990. Radioactivity detector. R. R. FOY AND F. CAMARENA. *Rev. Mexicana Fis.*, **2**, No. 1, 51–6 (Jan., 1953) In Spanish.

The design and function of a simple, portable, integrating detector is given. One control selects two sensitivities, one being ten times the other. The

max. sensitivity detects 5×10^{-10} A from the commercial Geiger counter of 3 cm dia. and 30.5 cm length. The other control alters the h.t. supply in 30 V steps from 900 V to 1050 V. In optimum conditions, cosmic rays have given $3 \times 10^{-8} \pm 5 \times 10^{-9}$ A. Within these fluctuations the microammeter reading is proportional to the number of disintegrations.

J. J. PHIPPS

539.16.08

3991. Techniques used at the Institute of Nuclear Physics of the University of Liège. II. Dosage of radiocarbon C^{14} . J. GOVAERTS. *Bull. Soc. Roy. Sci. Liège*, 23, No. 9–10, 297–307 (Sept.–Oct., 1954) In French.

See Abstr. 5751 (1953). Lauritsen electrometer and Nucleometer (windowless G.M. counter) are used. Samples are burned wet (in solution) or dry, the resulting CO_2 being transformed into $BaCO_3$. A graph shows the auto-absorption curve for $BaC^{14}O_3$, measured on a Nucleometer, as a function of layer thickness (in mg/cm^2). A technique is described of obtaining a uniform distribution of $BaCO_3$ on an Al layer.

F. LACHMAN

539.16.08

3992. Comparison of four national radium standards. *J. Res. Nat. Bur. Stand.*, 53, No. 5, 268–75 (Nov., 1954).

I. Experimental procedures and results. T. I. DAVENPORT, W. B. MANN, C. C. MCCRAVEN AND C. C. SMITH (268–72).

The two United States primary radium standards have been compared with the British primary radium standard and the Canadian national radium standard (1) by an ionization method, using the N.B.S. standard electroscop, (2) calorimetrically, using the Peltier-cooling radiation balance, (3) by means of a Geiger-Müller counter, and (4) using a scintillation counter. Where there is little or no difference in γ -ray source self-absorption, the four methods should, and in fact do, give good agreement. In the case of the Canadian national radium standard the difference in the results obtained is an indication of a difference in source self-absorption.

II. Statistical procedures and survey. W. S. CONNOR AND W. J. YODEN (273–5).

The statistical analysis of the observations on the four national radium standards is discussed. The readings made with the electroscop, Geiger-Müller counter, and scintillation counter were adjusted by one formula, and the readings made with the radiation balance by a different formula. In each case the adjusted values of the standards satisfy a consistency criterion. Finally, the adjusted values were improved by making use of the proportional relationship between the masses and the radioactive effects of the standards.

A.

539.16.08

3993. A radiation balance for the microcalorimetric comparison of four national radium standards. W. B. MANN. *J. Res. Nat. Bur. Stand.*, 53, No. 5, 277–81 (Nov., 1954).

The design of a radiation balance, a twin microcalorimeter utilizing the Peltier effect, to accommodate three Hönigschmid radium standards is described. The rate of energy production of radium

and its daughter products down to radium D, for unit mass of radium element in terms of all three Hönigschmid standards, was found to be equal to $138.6 \text{ cal. g}^{-1} \text{ hr}^{-1}$.

A.

539.16.08

3994. Adoption of a single [ionization] chamber for the measurement of a wide range of power-levels in a nuclear reactor. J. WEILL AND P. BRAFFORT. *J. Phys. Radium*, 16, No. 2, 155–8 (Feb., 1955) In French.

For low powers, the arrangement described uses a balanced ionization chamber, screened with bismuth to reduce γ -ray background. For high power a (boron) neutron absorber is added, giving an overall range of 9 decades. Geometrical details are discussed.

J. J. WILKINS

539.16.08

3995. Geometrical corrections in angular correlation measurements. A. M. FEINGOLD AND S. FRANKEL. *Phys. Rev.*, 97, No. 4, 1025–30 (Feb. 15, 1955).

It is shown that given a point-point angular correlation of the form $W(\theta) = \sum_i a_i P_i(\cos\theta)$, the experimentally measured angular correlation using finite-sized detectors of arbitrary shape and efficiency distributions is given by $W(\theta) = \sum_{lm} a_{lm} b_{lm} c_{lm} g_{lm}^{II} P_l(\cos\theta)$, where b_{lm} and c_{lm} are the Legendre coefficients describing the efficiency functions of the detectors, and g_{lm}^{II} are numerical coefficients. An extensive table of these latter coefficients, sufficient for most applications, is included. The manner in which detector symmetries of various types affect the form of the measured angular correlation is discussed; in particular it is shown that if the efficiency function of both counters is invariant to reflection about both horizontal and vertical axes, the measured angular correlation will contain no P_l 's of higher order than the P_l of highest order appearing in the point-point correlation. The above formula for the measured angular correlation is also shown to apply if an axially-extended source instead of a point source is used, the detector coefficients simply being replaced by a new set of suitably averaged coefficients. Tables of correction factors to fourth order in detector and axial source size are included for the special cases of rectangular and circular detectors of constant efficiency.

A.

539.16.08 : 539.172.3

3996. The radium equivalent of ^{24}Na sources and the photodisintegration cross section of deuterium. W. R. McMURRAY AND C. H. COLLIE. *Proc. Phys. Soc. [London] A*, 68, Pt 3, 181–8 (March, 1955).

A stable β -detecting proportional counter has been constructed and used in the β - γ coincidence method to calibrate a Curie chamber substandard for ^{24}Na γ -ray sources. The mg Ra equivalent of ^{24}Na is found to be $0.333 \pm 1.5\%$ mc. This calibration leads to a revised value of the deuterium photodisintegration cross-section at 2.76 MeV (15.05 ± 0.5 barn).

A.

539.16.08 : 550.9

3997. Carbon dioxide as a substitute for solid carbon in ^{14}C age measurements. T. A. RAFTER. *New Zealand J. Sci. Technol. B*, 36, No. 4, 363–70 (Jan., 1955).

Techniques developed for the preparation of carbon

dioxide gas for use in C^{14} age measurements are described. The gas can be produced free from electronegative contaminants and all but traces of radon. Such gas is suitable as a filling gas for a carbon-dioxide-filled proportional counter of volume eight litres.

A.

539.163.1

3998. A new determination of the half-life of Rb^{87} . I. GEESE-BÄHNISCH AND E. HUSTER. Note in *Naturwissenschaften*, **41**, No. 21, 495–6 (1954) In German.

The β -particle emission rate of Rb^{87} was obtained using thin conducting supporting films ($\sim 50 \mu g cm^{-2}$) and 4π -counter, giving $A_0 = 42.5$ β -particles (mg $RbCl$) $^{-1} min^{-1}$, and a $\frac{1}{2}$ -life of $4.3(^{+7\%}_{-4\%}) \times 10^{10}$ yr.

A. O. STANESBY

539.163.1

3999. Accurate measurements of radioactive half-lives. J. TOBAILEM. *J. Phys. Radium*, **16**, No. 1, 48–53 (Jan., 1955) In French.

These were made by a differential method using two ionization chambers feeding an electrometer triode. Radium was used as standard. Values obtained were: Na^{24} , 14.90 ± 0.05 hr; Co^{60} , 5.27 ± 0.07 yr; Cu^{64} , 12.80 ± 0.03 hr; Ga^{67} , 77.9 ± 0.3 hr; Au^{198} , 2.686 ± 0.005 days; Rn^{222} , 3.825 ± 0.005 days and Ac^{227} , 21.6 ± 0.4 yr.

A. O. STANESBY

539.163.1

4000. Upper limit for the lifetimes of excited states of Ni^{60} . Z. BAY, V. P. HENRI AND F. McLERNON. Letter in *Phys. Rev.*, **97**, No. 2, 561–3 (Jan. 15, 1955).

An account is given of a short-resolving-time ($\sim 10^{-10}$ sec) coincidence circuit using diphenyl acetylene scintillation counters. A value of 10^{-11} sec as an upper limit has been set on these lifetimes.

M. A. GRACE

539.163.1

4001. The half-life of Sr^{90} . D. M. WILES AND R. H. TOMLINSON. *Canad. J. Phys.*, **33**, No. 3–4, 133–7 (March–April, 1955).

The value of 27.7 ± 0.4 years has been obtained from the absolute disintegration rate of a known number of atoms. The disintegration rate was measured with a 4π proportional counter and the number of atoms was determined with a mass spectrometer using isotope dilution.

A.

539.163.2

4002. On the decay spectrum of $^{83}Bi^{214}$. R. RICCI AND G. TRIVERO. *R.C. Accad. Naz. Lincei*, **17**, No. 1–2, 44–6 (July–Aug., 1954) In Italian.

Beta–gamma coincidence techniques performed with β -absorption in different thicknesses of Al have confirmed the existence of a 3.17 MeV β -ray with no coincident γ -ray, attributed to the decay of Bi^{214} to the ground state of Po^{214} . Coincidences occur above 1.65 MeV, ceasing at 2.56 MeV. There is a 2.56 MeV β -ray with a coincident γ -ray which is not that of 0.61 MeV energy.

J. J. PHIPPS

539.163.2

4003. On the decay scheme of $^{84}Po^{212}$ (ThC'). F. DEMICHELIS. *R.C. Accad. Naz. Lincei*, **17**, No. 1–2, 46–7 (July–Aug., 1954) In Italian.

The decay scheme and energy levels of $^{84}Po^{212}$ are

deduced from data on the γ -rays emitted, and also from the long-range α -particles. The two schemes do not correspond exactly; it seems that there are levels, from which γ -rays are emitted, which do not give rise to long-range α -particles detectable in this experiment.

P. ROTHWELL

539.163.2

4004. $E3$ isomer in Ir^{191} . J. W. MIHELICH, M. McKEOWN AND M. GOLDBABER. Letter in *Phys. Rev.*, **96**, No. 5, 1450–2 (Dec. 1, 1954).

Available evidence is presented to show that the 42 keV transition in Ir^{191} is probably $E3$. A half-life measurement of 6.8 ± 1.0 sec is reported.

J. J. WILKINS

539.163.2

4005. 5.6 -second Ir^{191m} following Os^{191} decay. R. NAUMANN AND J. B. GERHART. Letter in *Phys. Rev.*, **96**, No. 5, 1452–3 (Dec. 1, 1954).

Isomerism in Ir^{191} has been found by chemically extracting it from the parent Os^{191} and identifying the X - and 129 keV γ -radiation which decays with a 5.6 ± 0.4 sec $\frac{1}{2}$ -life. It is concluded that this γ -ray follows a 42 keV γ -ray ($E3$ or $M3$) which is responsible for the isomerism.

M. A. GRACE

539.163.2

4006. Study of the disintegration of $^{81}Ti^{104}$. T. YUASA, J. LABERRIGUE-FROLOW AND L. FEUVRAIS. *J. Phys. Radium*, **16**, No. 1, 39–47 (Jan., 1955) In French.

The β -particle spectrum was examined in a thick-ens magnetic spectrometer using a thin ($30 \mu g cm^{-2}$) window counter. The shape of the β -spectrum ($E_{max} = 765 \pm 10$ keV) is discussed. No internal-conversion electrons were found in the energy range 215 – 315 keV; a study of the Auger electrons emitted gave K -capture/ $\beta^- \sim 3$ – 4% . No electromagnetic radiation apart from the 70 keV X-rays could be detected in a scintillation spectrometer.

A. O. STANESBY

539.163.2

4007. Neutron deficient isotopes of Pb and Tl. I. Isomers of Pb and Tl. I. BERGSTRÖM AND A. H. WAPSTRA. *Phil. Mag.*, **46**, 61–4 (Jan., 1955).

Summary of provisional results.

A. O. STANESBY

539.163.2

4008. Neutron deficient isotopes of Pb and Tl. II. Mass numbers 204, 202, 201, and 200. K. E. BERGKVIST, I. BERGSTRÖM, C. J. HERRLANDER, S. HULTBERG, H. SLÄTIS, E. SOKOLOWSKI, A. H. WAPSTRA AND T. WIEDLING. *Phil. Mag.*, **46**, 65–9 (Jan., 1955).

Preliminary results. γ -ray energies, K -conversion intensities and multipolarities are tabulated for Pb: 200, 201, $202m$ and $204m$, and Tl: 200 and 201.

A. O. STANESBY

539.163.2

4009. Neutron deficient isotopes of Pb and Tl. III. Mass numbers below 200. G. ANDERSSON, E. ARBMAN, I. BERGSTRÖM AND A. H. WAPSTRA. *Phil. Mag.*, **46**, 70–2 (Jan., 1955).

Preliminary results. Gamma-ray energies, K -conversion intensities and multipolarities are tabulated for Pb: 197, 198, 199 and $199m$, and Tl: 196 (?) and 197.

A. O. STANESBY

539.163.2
4010. Radiation dosimetry of rubidium-86. E. W. EMERY, J. E. S. BRADLEY AND N. VEALL. Letter in *Nature [London]* **175**, 34 (Jan. 1, 1955).

8.4% of the disintegrations give a γ -ray of energy 1.08 MeV, with a k factor 0.50 r/hr.mC. The β -ray energy, found by gelatin-lined chamber, is 0.66 MeV and the half-life 18.66 ± 0.026 days. F. T. FARMER

539.163.2
4011. On the disintegration of Rh^{102} . P. AVIGNON. *C.R. Acad. Sci. [Paris]* **240**, No. 2, 176–8 (Jan. 10, 1955) In French.

X^- and γ -ray measurements show that decay to Ru^{102} proceeds by electron capture ($\beta^+ < 10\%$). Seven γ -rays of energies between 125 and 1085 keV have been found, their relative intensities measured and multipole assignments suggested. M. A. GRACE

539.163.2
4012. The decay of ^{185}W . A. BISI, S. TERRANI AND L. ZAPPA. *Nuovo Cimento (Ser. 10)* **1**, No. 2, 291–9 (Feb., 1955).

The β - and γ -radiations from W^{185} have been investigated by means of an intermediate image β -spectrometer, a proportional counter spectrometer and a scintillation spectrometer. The disintegration has been found to be complex. It was found that the maximum energy of the main β -spectrum (90%) was 426 keV and that the β -transition goes to the ground state of Re^{185} . A faint γ -ray of 55.6 keV was detected and found to correspond to an excited level in Re^{185} . The γ -ray arises from a magnetic dipole transition. Spin and parity have been assigned; a decay scheme is proposed. A.

539.163.2
4013. Identification of Mo^{91} and Mo^{91m} . P. AXEL, J. D. FOX AND R. H. PARKER. *Phys. Rev.*, **97**, No. 4, 975–7 (Feb. 15, 1955).

The known 65 sec activity in Mo^{91} is shown to have an intense 650 ± 15 keV γ -ray. The 65 sec activity is therefore assigned to a 650 ± 15 keV isomeric level which decays by a γ -transition $70 \pm 10\%$ of the time and by positron emission $30 \pm 10\%$ of the time. There are at least two higher-energy γ -rays with energies 1.22 ± 0.03 MeV and 1.55 ± 0.03 MeV. Existing (γ, n) and ($n, 2n$) data are used to show that 65 sec, 650 keV Mo^{91m} is a $p_{1/2}$ state and that 15.5 min Mo^{91} is a $g_{7/2}$ state. This assignment implies that the neutron binding energy of Mo^{92} is 12.5 MeV. A.

539.163.2
4014. Disintegration of Te^{131} . E. HEBB. *Phys. Rev.*, **97**, No. 4, 987–90 (Feb. 15, 1955).

Investigations of the nuclear radiations from the 30 hour isomeric state of Te^{131} have been made with the help of magnetic lens spectrometers and scintillation counters. Beta-ray groups of end-point energies 2.46, 2.14, 1.69, 1.35, 0.98, 0.57 and 0.42 MeV have been found. The well-known internally converted 0.180 MeV transition, that from the 30 hour isomeric state of Te^{131} to the 25 min ground state, was reinvestigated, and its $K/(L + M)$ ratio of 2.4 corresponds to that of an $M4$ transition. Photoelectron spectra show well defined lines corresponding to γ -ray energies of 0.773, 0.446, 0.331, 0.147 and 1.12 MeV, and weaker lines corresponding to γ -ray

energies of 0.24, 0.275, 0.575, 0.84 and 1.63 MeV. Grey wedge pictures of NaI(Tl) scintillation spectra indicate that the 0.147 and 0.446 MeV transitions are the main lines appearing in the 25 min tellurium with the 0.773 MeV line also visible. Gamma-gamma scintillation coincidence experiments on the long-lived tellurium are utilized in establishing a possible decay scheme. A.

539.163.2
4015. Disintegration of As^{71} . W. E. GRAVES AND A. C. G. MITCHELL. *Phys. Rev.*, **97**, No. 4, 1033–6 (Feb. 15, 1955).

The disintegration of As^{71} , formed by the deuteron bombardment of separated Ge^{70} , has been investigated with the help of magnetic spectrometers, scintillation spectrometers, and coincidence counting. The half-life was found to be 62 ± 3 hour. Two γ -rays are emitted whose energies are 175.0 ± 0.3 keV and 23 keV. Positrons are emitted which have an end-point energy of 815 ± 10 keV. The state at 175 keV has a half-life of 0.07×10^{-6} sec. A tentative decay scheme is proposed. A.

539.163.2
4016. Isomeric state of Y^{88} in the decay of Zr^{88} . E. K. HYDE, M. G. FLORENCE AND A. E. LARSH. *Phys. Rev.*, **97**, No. 5, 1255–8 (March 1, 1955).

The 85 day activity Zr^{88} decays by electron capture to Y^{88m} which de-excites by emission of 395 keV γ -radiation with a half-life of 0.37 ± 0.03 millisecond. From the half-life and the conversion coefficient the transition is characterized as $E3$. A.

539.163.2
4017. Angular distribution of the resonance fluorescence radiation from the 411-keV excited state of Hg^{198} . F. R. METZGER. *Phys. Rev.*, **97**, No. 5, 1258–60 (March 1, 1955).

By using the Doppler broadening due to thermal agitation at elevated temperatures as a means of restoring the resonance condition, the angular distribution of the resonance fluorescence radiation from the 411 keV excited state in Hg^{198} has been measured. The observed distribution has the form $1 + (0.37 \pm 0.06)P_2(\cos\theta) + (1.07 \pm 0.08)P_4(\cos\theta)$, which agrees very well with the theoretical expectation for the excitation of a state with spin 2 from a ground state with spin 0. A.

539.163.2
4018. Coincidence studies of the disintegration of Pm^{151} and Nd^{147} . H. S. HANS, B. SARAF AND C. E. MANDEVILLE. *Phys. Rev.*, **97**, No. 5, 1267–71 (March 1, 1955).

Chemically pure Nd_2O_3 was irradiated by slow neutrons on five successive occasions in the Brookhaven pile. The 27.5 hour Pm^{151} was found to emit γ -rays of energies 64, 100, 163, 177, 240, 275, 340, 440, 650 and 700 keV. The 11-day Nd^{147} was shown to emit quanta of energies 92, 165, 280, 320, 410, 440, 530 and 690 keV. The relative intensities of the various quantum radiations have been determined, and coincidence measurements have been performed to ascertain the various sequential relationships between pairs of γ -rays. Partial decay schemes for both radionuclides have been indicated. A.

539.163.2
4019. Decay of Ti^{51} and Cr^{51} . M. E. BUNKER AND J. W. STARNER. *Phys. Rev.*, **97**, No. 5, 1272-5 (March 1, 1955).

The radiations of Ti^{51} (5.8 min) and Cr^{51} (27 day) have been investigated with β - and γ -scintillation spectrometers. Gamma-rays having energies of 0.323, 0.605 and 0.928 MeV and relative intensities of 95.8 : 1.4 : 4.2, respectively, were observed to accompany the decay of Ti^{51} . Two β -groups were observed of energy 2.13 and 1.5 MeV, having relative intensities of 94.4 and 5.6, respectively. The 2.13 MeV transition leads to the 0.323 MeV level of V^{51} . There is no evidence for a β -transition to the ground state of V^{51} . Cr^{51} decays by electron capture to both the ground state and the first excited state of V^{51} . The intensity of the capture branch to the 0.323 MeV level was measured to be 9.8%. A value of 3.25×10^{-3} was found for the total internal conversion coefficient of the 0.323 MeV γ -transition, indicating that the transition is $M1 + E2$. The spin and parity assignments suggested by the experimental data are discussed. A.

539.164 : 539.166
4020. Study of α - γ angular correlations in $\text{Io}(\text{Th}^{230})$. III. 250 keV level. P. FALK-VAIRANT AND G. Y. PETIT. *C.R. Acad. Sci. [Paris]* **240**, No. 3, 296-7 (Jan. 17, 1955) In French.

For Pt II, see Abstr. 8578 (1954). Measurements with an ionization chamber and a scintillation counter show that the 250 keV level of Ra^{226} has spin 1 and odd parity. J. J. WILKINS

539.164.1
4021. Branching ratio in the decay of polonium-210. R. W. HAYWARD, D. D. HOPPEs AND W. B. MANN. *J. Res. Nat. Bur. Stand.*, **54**, No. 1, 47-50 (Jan., 1955).

Using a micro-calorimeter to determine the α -particle activity and a sodium-iodide scintillation counter of high efficiency to measure the γ -ray intensity, the branching ratio of polonium-210 has been found to be equal to $(1.22 \pm 0.06) \times 10^{-5}$. This value is based on the assumption that the energy of the main α -particle group from polonium-210 is 5.301 MeV. In the calibration of the scintillation counter the angular anisotropy of the γ -rays from cobalt-60 was found to be 1.164 ± 0.002 . A.

539.164.2
4022. A formulation of the theory of alpha-particle decay from time-independent equations. R. G. THOMAS. *Progr. theor. Phys.*, **12**, No. 3, 253-64 (Sept., 1954).

The theory of α -particle decay is formulated from the time-independent R -matrix theory of nuclear reactions. It is shown that the most appropriate proper solutions are those with radial nodes near the channel radii, and therefore the Teichmann-Wigner sum rules involving the α -particle kinetic energy may be applied. Exact and approximate relations are given for the dependence on the angular momentum of the decay rate for the square-well model. Barrier penetration formulae are given which include estimates of the effects of an external nuclear exponential potential and atomic electron screening. A.

539.164.74
4023. Elastic scattering of alpha-Po particles on hydrogen. M. K. JURIC. *Atomics [London]* **5**, No. 12, 333-9 (Dec., 1954).

A critical study is given of the possibility of working with natural radioactive sources by means of photo-nuclear plates in order to determine the angular distribution and measure the energy of particles. To achieve this, targets containing hydrogen were irradiated in vacuum by Po α -rays and the angular distribution of recoil-protons was observed. A.

539.164.75 : 537.564
 Ionization and alpha-particle energy loss in different gases. See Abstr. 3853

539.165
4024. The importance of inelastic β - e^- scattering in radioactive sources. M. DUQUESNE. *C.R. Acad. Sci. [Paris]* **239**, No. 25, 1785-6 (Dec. 20, 1954) In French.

The effect of spurious (β - e^-) coincidences due to inelastic scattering of β -particles in the source material can be eliminated, with reasonably thin ($< 200 \mu\text{g. cm}^{-2}$ for P^{32}) sources by suitable choice of geometry. A. O. STANESBY

539.165
4025. Analysing beta absorption graphically to identify emitters. J. H. HARLEY AND N. HALDEN. *Nucleonics*, **13**, No. 1, 32-5 (Jan., 1955).

The energy of the β -ray spectrum from an active sample is determined by comparison with a standard source. The logarithm of the intensity of the radiation from the sample transmitted through an absorber is plotted against the same quantity for the standard source, for various thicknesses of absorber. The resulting graph is a straight line (if the β -spectrum is simple), the slope of the line depending upon the maximum energies of the spectra compared. P^{32} and Ca^{45} are convenient standards for high energy and low energy spectra respectively. Complex activities yield plots which may be analysed into straight lines if the energies are very different. L. R. SHEPHERD

539.165
4026. Study of electron capture in the disintegration of the nuclide Na^{22} . G. CHARPAK. *J. Phys. Radium*, **16**, No. 1, 62-5 (Jan., 1955) In French.

Using a 4π Geiger counter a very low-energy radiation from thin sources of Na^{22} was detected and attributed to Auger electrons following electron capture. The experimental ratio K -capture/ β^+ = $(6.5 \pm 0.9)\%$. The preparation of suitable very thin radioactive sources is discussed. A. O. STANESBY

539.165
4027. Decays of Ta^{182} and Ta^{183} . J. J. MURRAY, F. BOEHM, P. MARMIER AND J. W. M. DUMOND. *Phys. Rev.*, **97**, No. 4, 1007-16 (Feb. 15, 1955).

The β^- -decays of Ta^{182} and Ta^{183} into excited states of W^{182} and W^{183} have been studied using a curved crystal γ -ray diffraction spectrometer and a homogeneous-field, ring-focusing β -ray spectrometer. In each case de-excitation of the daughter nucleus gives rise to complex γ -ray and conversion electron spectra. Energies and relative intensities of γ -rays and conversion lines arising from 27 transitions in W^{182} and 29 transitions in W^{183} are presented. Internal conversion coefficients and multipolarities have been

deduced for most of the transitions and together with the γ -ray energies form the basis of decay schemes proposed for both W^{182} and W^{183} . The two decays are reported together because of the close experimental relationship which existed between them as a consequence of the method used for their production, namely, simultaneous production of Ta^{182} by single neutron capture and Ta^{183} by double neutron capture from stable Ta^{182} . A corollary result is the value 1.3×10^4 barn for the thermal neutron cross-section of Ta^{182} . An interpretation of these results on W^{182} in terms of collective rotational motion has been given by A. Bohr and collaborators [K. Danske Vidensk. Selsk, Mat.-fys. Medd., 29, No. 9 (1955)]. A.

539.165

4028. Radiations from cerium 141. J. T. JONES, JR AND E. N. JENSEN. *Phys. Rev.*, 97, No. 4, 1031-3 (Feb. 15, 1955).

The β -spectrum of Ce^{141} has been examined with an intermediate-image spectrometer adapted for coincidence measurements. The β -decay was found to be complex with two β -groups of maximal energies 574 ± 3 keV and 432 ± 2 keV. The data obtained indicated the presence of a single γ -ray, with an energy of 144.9 ± 0.7 keV. Coincidence measurements inferred that the γ -ray was in coincidence with the lower-energy β -group. Gamma-ray spectra obtained with a scintillation spectrometer and a thin-lens spectrometer indicated that only one γ -ray is present in Ce^{141} . Transitions ascribed to higher- and lower-energy β -groups are $\Delta I = -1$, "yes" and $\Delta I = 0$, "yes," respectively. The γ -ray is probably magnetic dipole radiation. An $f_{7/2}$ -state, with odd parity, is assigned to the ground state of Ce^{141} ; a $g_{7/2}$ -state, with even parity, is assigned to the first excited state of Pr^{141} . A.

539.165

4029. Beta-spectra of Ag110 and Sb124. T. AZUMA. *J. Phys. Soc. Japan*, 10, No. 3, 167-72 (March, 1955).

These were measured with a double-coil, magnetic-lens spectrometer of about 2% resolving power and their Fermi plots were studied. For the decay of Ag^{110} , it was found that the soft component of the continuous β -ray spectrum could be analysed into three groups of allowed type with end points at 80, 314 and 530 keV. For Sb^{124} , five β -ray groups with end points at 2.39, 1.68, 1.07, 0.63 and 0.28 MeV are found, in which the group of the highest energy is inferred as the first-forbidden mixed interaction for ST or VA shape. The results for Sb^{124} agree with other observers. A.

539.165 : 539.166

4030. β - γ -coincidence detection using a β -spectrometer and a scintillation spectrometer. Application to the study of the disintegration scheme of Sm^{153} . N. MARTY. *J. Phys. Radium*, 15, No. 12, 60 S-61 S (Dec., 1954) In French.

539.165.2

4031. Gamow-Teller interaction in the decay of He^6 . B. M. RUSTAD AND S. L. RUBY. *Phys. Rev.*, 97, No. 4, 991-1002 (Feb. 15, 1955).

The coefficient α in the electron-neutrino angular correlation $W(\phi) = [1 + \alpha(p/W) \cos \phi]$ for the He^6 - Li^6 transition has been determined by measuring the coincidence rate between recoil ions and β -rays of

selected energy as a function of the angle between the particles. Since the decay of He^6 (allowed ft value and $\Delta I = 1$) obeys only Gamow-Teller selection rules, the interaction Hamiltonian for this transition is specified completely by $(G_A A + G_T T)$. The measured values of the correlation coefficient are $\alpha_{1.25} = +0.36 \pm 0.11$ for β -rays with mean energy 1.25 MeV and $\alpha_{2.0} = +0.31 \pm 0.14$ for the mean energy 2.0 MeV. These results are compared with $\alpha_T = +\frac{1}{2}$ and $\alpha_A = -\frac{1}{2}$ predicted from the pure tensor and axial vector invariants, respectively. The limiting value set by the experiment for (G_A/G_T) together with the observed absence of the Fierz interference terms for allowed β -spectra proves that the tensor invariant is dominant in the β -decay interaction of He^6 . A.

539.165.2

4032. Search for double beta decay in Ca^{48} . J. A. MCCARTHY. *Phys. Rev.*, 97, No. 5, 1234-6 (March 1, 1955).

If double β -decay occurs without the emission of neutrinos, the total kinetic energy of the two emitted electrons is constant. An experiment has been performed using this constancy of energy and the coincidence nature of the activity in an attempt to observe and identify this process in Ca^{48} . The results show a peak in the total energy spectrum at 4.1 ± 0.3 MeV. Mass spectrographic data gives 4.3 ± 0.1 MeV as the available energy for double β -decay. The author believes this to be evidence for double β -decay without neutrino emission unless the observed counts are due to an unusual phenomenon of unknown origin. A.

539.166

4033. On a γ - γ -angular correlation in the decay of K^{42} . U. CAPPELLER AND R. KLINGELHÖFER. Note in *Z. Naturforsch.*, 9a, No. 12, 1052-4 (Dec., 1954) In German.

An anisotropy of $\sim 20\%$ in the γ - γ -angular correlation for K^{42} indicates the presence of a γ -ray cascade. The decay scheme is discussed.

A. O. STANESBY

539.166

4034. The spectrum of γ -rays from Rh^{102} . D. BÉS AND H. BOSCH. *C.R. Acad. Sci. [Paris]* 240, No. 3, 294-6 (Jan. 17, 1955) In French.

Scintillation spectrometer measurements are reported, covering the range 20-1800 keV. Rays were detected at 123, 195, 479, 633, 710, 880 (?), 1070, 1500 and 1720 keV.

J. J. WILKINS

539.166 : 539.172.13

4035. Gamma-rays from proton bombardment of sodium. K. NYBÖ AND T. GROTDAL. *Nature [London]* 175, 130 (Jan. 15, 1955).

Resonances in the γ -ray yield were found at 512, 592.3, 677, 743 and 873.7 (all ± 2) keV proton energies, with relative intensities 1, 3, 10, 4.5 and 9 respectively.

J. J. WILKINS

539.166 : 539.172.13

4036. Gamma radiation from the inelastic scattering of protons by F^{19} . C. A. BARNES. *Phys. Rev.*, 97, No. 5, 1226-33 (March 1, 1955).

The absolute cross-section for the excitation of the 109 keV and 197 keV excited states of F^{19} , by the

inelastic scattering of protons, has been studied as a function of bombarding energy up to 1750 keV by detecting the resultant γ -radiation in scintillation counters. Most of the resonances for the various $F^{19}(p, \alpha)O^{16}$ reactions appear as resonances for the excitation of one or both of these low-lying states. A detailed study of the angular distributions of the two γ -rays, together with the direct measurements of the lifetimes of these states by Thirion, Barnes and Lauritsen, and the Coulomb excitation work of Sherr, Li and Christy, leads to the assignments: 109 keV state, $J = \frac{1}{2}$, odd parity; 197 keV state, $J = \frac{5}{2}$, even parity. The non-resonant yield of 197 keV γ -rays is approximately that expected from Coulomb excitation at low incident proton energies. The non-resonant yield of 109 keV γ -rays exceeds the expected Coulomb excitation. In conjunction with previous measurements of the elastic scattering of protons by F^{19} and of the $F^{19}(p, \alpha)O^{16}$ reactions, the resonant inelastic cross-sections allow a new determination of the partial widths for the various modes of decay of the Ne^{20} compound nuclear states. A.

539.166 : 539.172.13

4037. Gamma rays from proton bombardment of Li^6 . S. BASHKIN AND R. R. CARLSON. *Phys. Rev.*, **97**, No. 5, 1245-9 (March 1, 1955).

A NaI(Tl) scintillation spectrometer, limited to 1.5 MeV γ -rays, detected 430 ± 20 keV radiation when separated Li^6 was bombarded with monochromatic protons from 180 keV to 415 keV. Spectrometer efficiency was measured using an Au^{198} source of β - γ -coincidences. The thick-target yield was $(7 \pm 4) \times 10^{-13}$ γ per proton at 180 keV and $(170 \pm 35) \times 10^{-13}$ at 415 keV. The 430 keV γ -ray was interpreted as part of the cascade decay of the broad 6.35 MeV state of Be^7 . Assuming s -wave capture, the experimental yield has been fitted with a Breit-Wigner resonance curve. At 415 keV, a cross-section of $0.7 \pm 0.2 \mu b$ is obtained for the decay of the capture state through the 430 keV state. This gives $(2J + 1)\Gamma_\gamma$ a value of 1.0 ± 0.3 eV for this cascade process. The spectrometer, when unlimited, detected γ -rays corresponding to transitions from the capture level to the ground and 430 keV states. The number of transitions from the capture state to the 430 keV state of Be^7 is $35 \pm 5\%$ of the total radiative decays. Transitions through the 4.65 MeV state of Be^7 occur in less than 4% of the total radiative decays. A.

539.166 : 539.172.4

4038. Gamma rays from 14-MeV neutron bombardment of C^{12} . M. E. BATTAT AND E. R. GRAVES. *Phys. Rev.*, **97**, No. 5, 1266-7 (March 1, 1955).

The γ -rays emitted by C^{12} under 14 MeV neutron bombardment have been investigated with a three-crystal pair spectrometer. In the energy range 1.5-5.5 MeV, the observed pulse-height distribution is consistent with the assignment of a single-energy line at 4.4 MeV. The calculated value for the production cross-section of 4.4 MeV γ -radiation is 245 ± 35 millibarn. A.

539.166.08

4039. Influence of the distance between source and crystal on the detection-efficiency of a gamma-scintil-

lation spectrometer. L. H. T. RIETJENS, G. J. ARKENBOUT, G. F. WOLTERS AND J. C. KLUYVER. *Physica*, **21**, No. 2, 110-16 (Feb., 1955).

For γ -rays of energy larger than 400 keV the efficiency may vary by a factor of two depending on the distance from source to crystal. The experimentally observed dependence may be fully explained by simple geometrical arguments. A.

539.166.74

4040. Internal Rayleigh scattering. A. M. COR-MACK. *Phys. Rev.*, **97**, No. 4, 986 (Feb. 15, 1955).

Calculations of the classical analogue of the elastic (Rayleigh) scattering of γ -rays by the electrons belonging to the γ -emitting nucleus have been made. The scattered radiation is a very small fraction of the unscattered radiation and they are indistinguishable if the electron distribution is spherically symmetrical about the nucleus. A.

539.166.835

4041. Multiple photon production in electron-positron annihilation. S. N. GUPTA. Letter in *Phys. Rev.*, **96**, No. 5, 1453 (Dec. 1, 1954).

At very high energies the probability for highly multiple production becomes comparable with that of double production. This is a possible explanation of the origin of a shower of 20 photons found by Schein *et al.* [Abstr. 10304 (1954)]. G. E. BROWN

539.166.835 : 537.591.1

4042. Electron pairs in cosmic rays: momentum transfer from very-high-energy photons. M. AVAN AND L. AVAN. *J. Phys. Radium*, **16**, No. 2, 97-100 (Feb., 1955) In French.

The behaviour of the recoil nucleus in the centre-of-mass system for very-high-energy pair production is studied and compared with theoretical predictions from the Bethe-Heitler theory. The effect of electron screening of the nucleus is also considered. The observations were made using photographic emulsions of the Ilford G.5 type. A. J. EGGINTON

539.167.3

4043. A new method for separation of radioactive iodine-131. K. TAUGBÖL AND K. SAMSAHL. *JENER Rep.*, No. 34, 5 + i pp. (1954).

A dry distillation method for separating radioactive iodine-131 from irradiated tellurium dioxide has been worked out. As far as the method has been tested, it seems to have several advantages over the previous one [Abstr. 3824 (1954)]. The tellurium dioxide can be used repeatedly, giving extremely high specific activity, and a minimum of other chemicals are needed for the separation. The new method is less time consuming than the old one. The yield exceeds 90%. A.

539.169

4044. Radon released from concrete in radiant heating. A. F. GABRYSH AND F. J. DAVIS. *Nucleonics*, **13**, No. 1, 50 (Jan., 1955).

Determinations of the radon released, on heating concretes containing uranium-bearing materials, indicate that serious concentrations could occur in the air inside buildings constructed from such concretes.

It is suggested that materials having a U concentration above 0.004% should be avoided.

L. R. SHEPHERD

NUCLEAR REACTIONS 539.17

539.17

4045. Theory of nuclear reactions with the production of slow particles. A. B. MIGDAL. *Zh. eksper. teor. Fiz.*, **28**, No. 1, 3-9 (1955) In Russian.

General remarks are made on problems in which the kinetic energies of some off-coming nucleons are small compared with their energy of interaction. An example is the collision of a fast nucleon with the deuteron, two of the final nucleons being in a bound state or a state of low relative momentum. The energy dependence of such processes is obtained.

G. E. BROWN

539.17 : 523.877

4046. On the rate of thermonuclear energy generation in stars. D. BOSMAN-CRESPIN, W. A. FOWLER AND J. HUMBLET. *Bull. Soc. Roy. Sci. Liège*, **23**, No. 9-10, 327-39 (Sept.-Oct., 1954) In French.

Improved numerical values are given for the rate of generation E for the CN-cycle and for the proton-proton chain for the temperature range 10^6 to 5×10^7 °K. Values of $d(\log E)/d(\log T)$ are computed at intervals throughout this range.

R. A. NEWING

539.172

4047. Concept of parentage of nuclear states and its importance in nuclear reaction phenomena. A. M. LANE AND D. H. WILKINSON. *Phys. Rev.*, **97**, No. 5, 1199-204 (March 1, 1955).

The concept of fractional parentage of nuclear states is invoked to point out that many dynamical properties of nuclear systems (transition rates and level widths) are controlled by products of the coefficients of fractional parentage for common parents (the "parentage overlap") between initial and final states. Illustrations are given from a range of nuclear reactions including radiative transitions, high- and low-energy stripping, pickup and photonuclear processes. It is particularly to be emphasized that, because of the occurrence of the coefficients of fractional parentage and certain (vector coupling) weighting factors in the expression for the transition rate, one may find reduced and radiative widths very considerably less than the "single-particle" values even though the states concerned are wholly of an independent-particle character; enhanced transitions are also possible within the same scheme.

A.

539.172

Nuclear reactions due to cosmic rays. See also under "Cosmic rays." Decimal classification 537.591.8

539.172.11/13

4048. Analysis of secondary particles resulting from high-energy nuclear bombardment. R. W. DEUTSCH. *Phys. Rev.*, **97**, No. 4, 1110-23 (Feb. 15, 1955).

Experimental studies have been made of the low-energy yields of secondary particles resulting from high-energy bombardment. For this purpose, thin

foils of Be, Al, Ni, Ag, Au and U have been bombarded by an internal beam of 375 MeV α 's, 332 MeV protons and 187 MeV deuterons. Secondary particles emerging from the disintegration of the nucleus at 0° to the incident beam direction are magnetically analysed and detected in nuclear emulsions located beneath the median plane of the 184 in. cyclotron. There are three specific positions for these emulsions corresponding to energies of the secondary protons and of α -particles of approximately 6, 10 and 20 MeV. This apparatus was modified to make a special study of the secondary α and proton yields by including two extra plates so that 10 energy points could be taken in the range from approximately 5 to 22 MeV. The angular distribution of secondary particles has also been measured for 240 MeV α -bombardment of Be, Al, Ni and Ag. Here, secondary particles emitted at 0°, 45° and 135° are detected in nuclear emulsions at positions for which the secondary proton and α -energy is approximately 6 MeV. A secondary particle is identified by measurement of its radius of curvature upon entering the emulsion and its range and specific ionization in the emulsion. A considerable yield of hydrogen and helium isotopes as well as of particles of higher atomic number is found. The relative yields of the secondary protons and α -particles for each element and for each bombardment are shown as a function of energy. The results, while found to be consistent with the predictions of an evaporation model, also indicate that a large percentage of secondary protons and α 's are directly knocked out of the nucleus.

A.

539.172.13 : 523.877

Nuclear reactions in stars: protons on light nuclei. See Abstr. 3405

539.172.13

4049. Emission of α -particles from nuclei excited by 50, 100, 150 and 450 MeV protons. M. GRILLI, B. VITALE, P. E. HODGSON AND M. LADU. *Nuovo Cimento (Ser. 10)* **1**, No. 2, 314-23 (Feb., 1955) In Italian.

The photographic emulsion technique is used to investigate the disintegration of nuclei excited by monoenergetic protons. The angular and energy distributions of the secondary particles show an excess in the forward direction, and this excess is greater for the secondary particles of high energy than for those of low energy. A correlation was found between the directions of emission of the secondary particles and that of the recoil fragments from the heavy nuclei, but no significant correlation was found between the energies and angles of emission of the secondary particles. These features of the disintegrations can be accounted for by the cascade-evaporation process, with the exception of the forward excess of α -particles. Several possible explanations of this effect, including direct knock-on, emission from a part of the nucleus excited to an abnormally high temperature and multiple pickup, are discussed.

A.

539.172.13

4050. Tantalum spallation and fission induced by 340-MeV protons. W. E. NERVIK AND G. T. SEABORG. *Phys. Rev.*, **97**, No. 4, 1092-109 (Feb. 15, 1955).

Nuclides formed as spallation and fission products

during bombardment of tantalum metal with 340 MeV protons in the 184 in. Berkeley cyclotron were separated chemically, identified and their formation cross-sections were calculated. A very broad fission peak which extends from mass 20 to mass 132 is observed. The maximum fission yield occurs in the region of the nuclide Kr^{83} and analysis of a set of contour curves fitted to the data indicates that either Hf^{166} or Lu^{166} is "the most probable fissioning nucleus." The total cross-section for fission is estimated to be 4.1 mb. Comparison of the fission data of tantalum with those of uranium and bismuth under the same bombardment conditions indicates that asymmetric fission is much more probable in tantalum than in either of the other elements. In the spallation region it is observed that neutron emission is the predominant spallation reaction. Integration under the spallation yield curve indicates that of those tantalum target nuclei which received at least enough excitation energy to reach the region of "the most probable fissioning nucleus" less than 1% undergo fission; the remainder undergo spallation reactions. Activities which have been observed here for the first time include a 136 min rhodium activity which has tentatively been assigned as an isomer of Rh^{107} ; 29.4 hour Er^{160} ; 5.0 hour Ho^{160} ; and 74 min Yb^{167} . A.

539.172.13

4051. Spallation of elements in the mass range 51–75. S. G. RUDSTAM. *Phil. Mag.*, **46**, 344–56 (March, 1955).

Empirical formulae for the yields of the products obtained in spallation reactions with high-energy particles are constructed. These formulae reproduce most of the experimentally determined cross-sections within a factor of 2, and they simplify the comparison between different spallation investigations. A.

539.172.13

4052. The spin, energy and lifetime of ^9Be . P. B. TREACY. *Proc. Phys. Soc. [London] A*, **68**, Pt 3, 204–13 (March, 1955).

Coincidences are used in studying the $\text{B}^{11}(p, \alpha)\text{Be}^8(\alpha)\text{He}^4$ reaction to infer directional correlations between successively emitted α -particles. From this the spin of the ground state of Be^8 is found to be zero and its break-up energy 90 ± 5 keV. The absence of any measurable loss of kinetic energy in the Be^8 nucleus when recoiling into a dense material enables us to place an upper limit on its half-life of 4×10^{-15} sec, which confirms the assignment of zero spin. A.

539.172.13

4053. The elastic scattering of protons by helium 3. D. R. SWEETMAN. Letter in *Phil. Mag.*, **46**, 358–60 (March, 1955)

A polythene foil was bombarded by the internal He^3 beam of the Birmingham cyclotron, and the scattered protons received on a nuclear plate. Use of a carbon foil gave the background of singly-charged particles to be expected due to $\text{He}^3\text{-C}$ reactions. The cross-section for $p\text{-He}^3$ scattering was measured at various centre-of-mass angles for a c.m. energy of 3.72 MeV. Up to 90° the scattering agrees well with the theory of Swan but then diverges, the experimental

cross-section rising to more than three times the theoretical at 150° .

J. H. FREMLIN

539.172.13

4054. Electric excitation of heavy nuclei by protons. C. MCCLELLAND, H. MARK AND C. GOODMAN. *Phys. Rev.*, **97**, No. 5, 1191–9 (March 1, 1955).

Electric excitation of nuclei has been used to study the low-lying level structure in heavy nuclei. Experimental data for seventeen nuclides are presented, including isotopes of lutecium, hafnium, tantalum, tungsten, rhenium and platinum. Excitation of twenty-five levels in these nuclei was observed. These data have been interpreted in terms of the hypothesis of nuclear rotational levels proposed by Bohr and Mottelson. Approximate intrinsic electric quadrupole moments of these nuclides determined in two ways from the experimental data are compared and interpreted as evidence for non-uniformity of the charge-mass distribution in nuclei. A.

539.172.13

4055. Reaction $p + p \rightarrow \pi^+ + d$. F. S. CRAWFORD, JR AND M. L. STEVENSON. *Phys. Rev.*, **97**, No. 5, 1305–13 (March 1, 1955).

Absolute differential cross-sections for the reaction $p + p \rightarrow \pi^+ + d$ have been measured at incident proton energies (lab system) from 310 to 338 MeV and at meson angles (c.m.) from 30° to 90° . The two final particles were counted in coincidence. The data are well fitted by the phenomenological theoretical expression $4\pi(d\sigma/d\Omega)(\text{c.m.}) = \alpha_{10}\eta + \beta_{10}\eta^3[(x + \cos^2\theta)/(x + \frac{1}{3})]$, with $x = 0.082 \pm 0.034$, $\alpha_{10} = (0.138 \pm 0.015) \times 10^{-27} \text{ cm}^2$ and $\beta_{10} = (1.01 \pm 0.08) \times 10^{-27} \text{ cm}^2$; θ = meson c.m. angle and $\eta = p(\text{c.m.})/m_{\pi c}$. By measuring α_{10} the amount of s -wave in this reaction was determined directly. Further measurements with polarized protons of ~ 315 MeV are presented. These confirm directly the presence of interfering s - and p -waves and give a result $|Q| = 0.39 \pm 0.05$ for the asymmetry $(R - L)/(R + L)$ which would be obtained at 90° c.m. with 100% polarized protons. The polarized and unpolarized results are used together to determine the relative phases of the s - and p -wave mesons. Using the recent Chicago measurement of the sign of the proton polarization, the sign observed for meson production asymmetry shows that spin-up protons produce more mesons to the right than to the left. The sign of this result, according to a theoretical prediction of B. T. Feld, provides strong evidence in favour of the Fermi type meson-nucleon interaction, and against the Yang type interaction. A.

539.172.13

4056. Polarization of nucleons elastically scattered from nuclei. R. M. STERNHEIMER. *Phys. Rev.*, **97**, No. 5, 1314–24 (March 1, 1955).

The polarization P of nucleons elastically scattered from nuclei has been calculated for the nuclear potential of Woods and Saxon which has the radial dependence $1/[1 + \exp\{(r - r_0)/a\}]$, where r_0 is the nuclear radius and the parameter a determines the length of the exponential tail. The variation of P with the optical parameter k_1/K and the strength of the spin-orbit coupling was investigated for the case of Al. In general, P remains positive throughout the

first diffraction minimum. For the Berkeley data for the polarization of 300 MeV protons scattered from Al, a reasonable fit has been obtained inside the first diffraction peak. The functions β and R introduced by Wolfenstein to describe the asymmetry in a triple scattering experiment are evaluated for several cases.

A.

539.172.13 : 537.591

4057. Tritium production by 2.2-BeV protons on iron and its relation to cosmic radiation. E. L. FIREMAN. *Phys. Rev.*, **97**, No. 5, 1303-4 (March 1, 1955).

The cross-section for tritium production by 2.2 BeV protons on iron is measured to be 62 ± 7 mb. This tritium cross-section indicates that $(1.4 \pm 0.4) \times 10^{-3}$ tritons/g.sec would be produced in small iron meteorites (a few inches in radius) in space by cosmic rays of the intensity of those striking the earth's polar regions. In 4×10^9 years, $6 \pm 2 \times 10^{-6}$ cm³ of He³ per gram of iron results from this cosmic-ray tritium. Mount Ayliff meteorite contains 11.5×10^{-6} cm³ of He³ per gram, indicating its bombardment by a cosmic-ray flux at least as intense as is presently striking the earth. The variation of tritium with target depth is also measured and indicates a decrease less rapid than an attenuation due to geometric cross-section.

A.

539.172.13

4058. Proton groups from deuteron bombardment of Ne²⁰ by magnetic analysis. II. K. AHN LUND. *Ark. Fys.*, **9**, Paper 3, 39-40 (1954).

For previous part, see Abstr. 5960 (1954). Using 855 keV deuterons the Q -value ($Q_3 = 1.738 \pm 0.008$ MeV) for the proton group leading to an excited state of Ne²¹ has been measured. No evidence for the group Q_2 reported by other authors was found.

M. A. GRACE

539.172.13

4059. The reaction energies of O¹⁷(d, p)O¹⁸ and C¹³(d, p)C¹⁴. K. AHN LUND, S. THULIN AND R. PAULI. *Ark. Fys.*, **8**, Paper 48, 489-94 (1954).

Targets rich in O¹⁷, and containing some C¹³, were prepared by electromagnetic separation methods. Ground-state reaction energies were measured using a magnetic spectrometer, with the results 5821 ± 10 keV and 5953 ± 10 keV.

J. J. WILKINS

539.172.13

4060. Theory of (d, p) and (d, n) reactions. II. Coulomb corrections and numerical results. I. P. GRANT. *Proc. Phys. Soc. [London] A*, **68**, Pt 3, 244-56 (March, 1955).

The results of Pt I [Abstr. 1191 (1955)] are generalized to take account of the effect of the Coulomb field on the differential cross-section in a deuteron stripping reaction. The results, which are expressed in analytical form, are compared in detail with the observations in two reactions using Be⁹ as target nucleus at low energies.

A.

539.172.13

4061. Angular distributions of deuteron-induced reactions in lithium. S. H. LEVINE, R. S. BENDER AND J. N. MCGRUE. *Phys. Rev.*, **97**, No. 5, 1249-54 (March 1, 1955).

Angular distributions of (d, t), (d, He^3), (d, p) and

(d, d') reactions have been obtained using a natural lithium target. Butler type calculations for $l = 1$ transfer fit all of the above data except for the (d, d') reactions. A Q value of 0.974 ± 0.015 MeV has been assigned to the first excited level in Li⁸. The He⁵ ground state was observed with the two reactions Li⁷(d, α)He⁵ and Li⁶(d, He^3)He⁵ for which the Q values were 14.26 ± 0.09 MeV and 0.91 ± 0.09 MeV respectively.

A.

539.172.3

4062. Sum-rules for photodisintegration of the deuteron. J. S. LEVINGER. *Phys. Rev.*, **97**, No. 4, 970-4 (Feb. 15, 1955).

The experimental total cross-section for photodisintegration of the deuteron is integrated numerically to 155 MeV for three moments of the curve weighting with W^{-1} , 1 and W respectively: the bremsstrahlung-weighted cross-section, the integrated cross-section and $\bar{W}\sigma_{\text{int}}$. The integrated cross-section is compared with the phenomenological sum-rule calculation, and also with the dispersion-theoretic calculation; all three values are in reasonable agreement, giving an integrated cross-section about 30% higher than that of 30 MeV mb for the Thomas-Reiche-Kuhn dipole sum-rule. There is good agreement between the experimental value of 3.9 mb and the phenomenological calculation of 3.78 mb for the bremsstrahlung-weighted cross-section.

A.

539.172.3

4063. Excitation function for the reaction ⁷Li(γ, t)He up to 21 MeV. M. MIWA. *J. Phys. Soc. Japan*, **10**, No. 3, 173-5 (March, 1955).

This was studied using betatron bremsstrahlung and nuclear emulsions, the statistics being much better than with former workers. Resonance peaks were found at the excitation energies of 7.6, 8.6, 9.6, 11.7 (13.5) and 16.2 MeV, 9.6 and 16.2 MeV peaks being the most predominant. The results were in good agreement with those of Titterton and Brinkley in general trend and in the most predominant peaks of the excitation function.

A.

539.172.3

4064. The measurement of photoneutron yields with a sodium iodide crystal. K. G. MCNEILL. *Phil. Mag.*, **46**, 321-6 (March, 1955).

It is shown that a NaI(Tl) crystal will act as a detector of photoneutrons by virtue of the production of radioactive I¹²⁸ within the crystal. This detecting technique has been applied to the comparison of the photoneutron yields obtained from copper, cadmium, mercury and lead when these elements are irradiated with a bremsstrahlung X-ray beam of maximum energy of 22 MeV. The yields from these four elements are found to be in the ratios Cu : Cd : Hg : Pb as 1 : 4.1 : 9.5 : 8.4.

A.

539.172.3

4065. Photoproduction of neutral pions in hydrogen: $p-\gamma$ coincidences. R. L. WALKER, D. C. OAKLEY AND A. V. TOLLESTRUP. *Phys. Rev.*, **97**, No. 5, 1279-82 (March 1, 1955).

Reports measurements of the differential cross-section for photoproduction of neutral pions in

hydrogen at energies 300, 400 and 450 MeV, at centre-of-momentum angles of 70° to 150° . One decay photon from the neutral pion is observed in coincidence with the recoil proton, whose energy and angle are measured to define the photon energy. The results obtained by this method are in good agreement with more accurate measurements obtained recently by the method of observing only the recoil proton.

A.

539.172.3

4066. Photoproduction of neutral pions in hydrogen: magnetic analysis of recoil protons. D. C. OAKLEY AND R. L. WALKER. *Phys. Rev.*, **97**, No. 5, 1283–91 (March 1, 1955).

The photoproduction of neutral pions from hydrogen has been studied by counting the recoil protons with a magnetic spectrometer and scintillation counters. The process has been studied between photon energies of 260 and 450 MeV and between centre-of-momentum pion angles of 70° and 153° . The excitation functions show a resonance type shape with maxima at about 320 MeV. Angular distributions are analysed in the form $A + B \cos\theta + C \cos^2\theta$ in the centre-of-momentum system. The coefficient B , which gives the front-back asymmetry, is small at all energies; and the ratio $-A/C$ is 1.22 ± 0.10 at all energies between 295 and 450 MeV. The maximum cross-section at 90° in the c.m. system is $26 \times 10^{-30} \text{ cm}^2/\text{steradian}$ for 320 MeV photons. The total cross-section divided by the square of the c.m. photon wavelength has a maximum near 340 MeV, and drops by nearly a factor of two at 450 MeV. These results are consistent with magnetic dipole and electric quadrupole absorption leading to a resonant state of the pion-nucleon system of angular momentum $\frac{3}{2}$ and isotopic spin $\frac{3}{2}$.

A.

539.172.3

4067. Yields of photonuclear reactions with 320-MeV X-rays. I. Experimental results. R. J. DEBS, J. T. EISINGER, A. W. FAIRHALL, I. HALPERN AND H. G. RICHTER. *Phys. Rev.*, **97**, No. 5, 1325–7 (March 1, 1955).

Several medium weight target elements were irradiated by 320 MeV bremsstrahlung. For each target, relative yields were determined for the production of a number of radioactive nuclides.

A.

539.172.3 : 539.16.08

Photodisintegration cross-section of deuterium. See Abstr. 3996

539.172.4

4068. Cross-sections of atomic nuclei for the (n, p) reaction. Z. WILHELMI. *Acta phys. Polon.*, **13**, No. 4, 243–74 (1954).

The cross-sections of Mg^{25} , Al^{27} , Cr^{52} , Fe^{56} , As^{75} , Sn^{116} and Sn^{118} nuclei were measured. Neutrons were used from the $\text{Li}(d, n)$ reaction with the deuteron energy 0.75 MeV. A simple method was worked out for determining the correction for scattering and absorption of β -electrons in the material of the irradiated samples. Two new reactions: $\text{Sn}^{116}(n, p)\text{In}^{116}$ and $\text{Sn}^{118}(n, p)\text{In}^{118}$ were discovered. The results obtained were compared with cross-sections calculated on the basis of Weisskopf's and Ewing's theory. The

causes of discrepancies are discussed, taking into consideration the dependence of the cross-sections on the radius and temperature of the nucleus, and on the threshold of the reaction.

A.

539.172.4

4069. The reaction cross-sections of $S(n, \alpha)\text{Si}$ and $S(n, p)\text{P}$ for neutron energies of 2.2 to 4.0 MeV. T. HÜRLIMANN AND P. HUBER. *Helv. phys. Acta*, **28**, No. 1, 33–48 (1955) In German.

The reactions $S^{32}(n, p)\text{P}^{32}$, $S^{32}(n, \alpha)\text{Si}^{29}$ and $S^{32}(n, \alpha)\text{Si}^{29*}$, leading to the ground state of P^{32} and the ground and first excited states of Si^{29} , respectively, have been studied by use of an ionization chamber filled with SO_2 . Pulses were analysed by means of a pulse spectrometer. The cross-sections for the three reactions are complicated functions of neutron energy. The (n, p) and (n, α) reactions occur with approximately equal frequency, but cross-section maxima for the two reactions do not coincide. The ratio $\sigma[S(n, \alpha)\text{Si}^*]/\sigma[S(n, \alpha)\text{Si}]$ is much greater than would be expected from the Coulomb barrier penetration argument.

A.

539.172.4

4070. Elastic scattering of neutrons by carbon in the energy range 1.92 MeV to 3.84 MeV. R. BUDDE AND P. HUBER. *Helv. phys. Acta*, **28**, No. 1, 49–66 (1955) In German.

The relative differential cross-section for elastic scattering of neutrons by carbon has been measured by means of an ionization chamber for neutrons of energy 1.92 MeV to 3.84 MeV from a (d, d) source. A phase analysis demonstrates the existence of three energy levels in the compound nucleus C^{13} , two of the $\text{D}_{3/2}$ -type and one for which $l > 1$. For a source at a deuteron energy of 600 keV and at an angle of neutron emission of 45° relative to the direction of the incident deuterons, the degree of polarization of the neutrons is $(18 \pm 7)\%$. The spin orientation of the polarized neutrons is parallel to the vector $[\vec{v}_n, \vec{v}_d]$. When CS_2 vapour was employed as a gas in the ionization chamber, three groups of α -particles were observed, corresponding to the reaction $S^{32}(n, \alpha)\text{Si}^{29}$ leading to the ground state and the first two excited states of Si^{29} .

A.

539.172.4

4071. Inelastic collision cross-sections at 1.0-, 4.0- and 4.5-MeV neutron energies. J. R. BEYSTER, R. L. HENKEL AND R. A. NOBLES. Letter in *Phys. Rev.*, **97**, No. 2, 563–4 (Jan. 15, 1955).

A table of inelastic scattering cross-sections for neutrons from the $\text{T}(p, n)\text{He}^3$ reaction is given for 16 elements. These were obtained by measuring the transmission through spherical shells of these materials surrounding a biased neutron detector.

M. A. GRACE

539.172.4

4072. Scattering of fast neutrons in Pb and Ag. T. W. BONNER, F. ALBA, A. FERNÁNDEZ AND M. MAZARI. *Phys. Rev.*, **97**, No. 4, 985 (Feb. 15, 1955).

The total cross-section for neutron scattering in lead and silver has been measured using monoenergetic neutrons with energies which were varied from 12.9 to 16.2 MeV. The total cross-section in silver becomes

smaller as the energy is increased, while the cross-section in lead is greater at the higher neutron energies. In the case of lead there appears to be a broad maximum in the cross-section curve at a neutron energy of 16 MeV. A.

539.172.4

4073. A simple model of the Li^6 nucleus and the $\text{Li}^6(n, t)\text{He}^4$ reaction. J. DABROWSKI AND J. SAWICKI. *Phys. Rev.*, **97**, No. 4, 1002-3 (Feb. 15, 1955).

A model of the Li^6 nucleus consisting of an α -particle plus a deuteron is used to calculate angular distributions of the $\text{Li}^6(n, t)\text{He}^4$ reaction for several neutron energies under the assumption that it is a pickup process. The shapes of the calculated angular distributions are similar to those of the experimental data; however, there is a lack of agreement between experiment and theory at large angles that is ascribed to compound nucleus formation. A.

539.172.4

4074. Neutron capture cross section of Ta^{182} . E. DER MATEOSIAN. *Phys. Rev.*, **97**, No. 4, 1023-4 (Feb. 15, 1955).

The neutron capture cross-section of Ta^{182} was measured by comparing the β -activity of Ta^{182} with that of Ta^{183} in a sample of irradiated tantalum. The β -activities were compared by growing a NaI(Tl) single crystal containing in it a trace of irradiated Ta and using this crystal as a scintillation detector for its internal source. This technique, here called "internal source spectrometry," allows one to realize a 4π solid-angle geometry, $\sim 100\%$ efficiency for particles, and effectively zero source thickness, and is thus eminently suited to problems in which it is desirable to perform a comparison of the intensities of two or more β -activities over periods of time equal to weeks or months. A knowledge of the decay scheme is not necessary for this method, provided there are no "delayed" internal conversion electrons. A value of 47000 ± 5000 barn was obtained for the capture cross-section of Ta^{182} for pile neutrons. A.

539.172.4

4075. The emission of alpha particles from argon under bombardment with neutrons. E. H. BELLAMY AND F. C. FLACK. *Phil. Mag.*, **46**, 341-3 (March, 1955).

Groups of particles have been observed using a high pressure gridded ionization chamber. The chief reaction is $\text{A}^{40}(n, \alpha)\text{S}^{37}$ with a measured Q -value of -2.5 ± 0.1 MeV, and transitions were observed to excited levels in S^{37} at 1.3 ± 0.05 , 2.2 ± 0.1 and 2.7 ± 0.1 MeV. The cross-section for the ground state transition is approximately $30\mu\text{barn}$. A.

539.172.4

4076. Cross sections for nonelastic interactions of 14-MeV neutrons with various elements. E. R. GRAVES AND R. W. DAVIS. *Phys. Rev.*, **97**, No. 5, 1205-12 (March 1, 1955).

The multiplication of neutrons by thin spherical shells of various materials surrounding a point source of 14 MeV neutrons has been measured. A special long counter was used whose energy response is independent of neutron energy over a range of energies from about 1 MeV to 14 MeV. The trans-

mission of primary energy neutrons through the shells has been measured with a trans-stilbene detector and values of the inelastic collision cross-sections have been derived. The quantity $\sigma_{n,2n} + 2\sigma_{n,3n} - \sigma_c$ is calculated, where $\sigma_{n,2n}$ and $\sigma_{n,3n}$ are the cross-sections for $(n, 2n)$ and $(n, 3n)$ reactions and σ_c is the sum of the cross-sections of all processes which destroy a neutron. Upper and lower limits are derived for $\sigma_{n,2n}$, σ_c and σ_{is} (inelastic scattering) for all materials investigated. For a number of materials specific values for the cross-sections are obtained. A.

539.172.4

4077. Cross section for excitation of Pb^{207m} by inelastic scattering of neutrons. P. H. STELSON AND E. C. CAMPBELL. *Phys. Rev.*, **97**, No. 5, 1222-6 (March 1, 1955).

The cross-section for the excitation of the 0.8 sec metastable state of Pb^{207} by inelastic neutron scattering has been measured for neutron energies up to 3.1 MeV. Neutrons were produced by the $\text{Li}(p, n)$ reaction. The lowest neutron energy for which excitation is observed is 1.6 MeV. This is in agreement with the level scheme for Pb^{207} based on other information. For the first 800 keV above threshold, the cross-section rises approximately linearly, attaining a value of 75 millibarn at 2.4 MeV. After levelling off, it abruptly increases at 2.75 MeV and has a value of 190 millibarn at 3.1 MeV. It is judged that the absolute values of the cross-section are accurate to $\pm 40\%$. The absolute cross-section for excitation of the metastable state as a function of neutron energy is calculated by the use of the strong interaction theory of nuclear reactions. The theoretical predictions agree well with the measured curve. A.

539.172.4 : 539.185.7

Four classic papers on neutron absorption. See Abstr. 4110-13

539.172.4

4078. Electric model of a nuclear reactor. C. V. OCÓN. *Rev. Mexicana Fis.*, **3**, No. 4, 229-35 (Oct., 1954) In Spanish.

Two electric networks are proposed: reproducing specified transfer functions of the Argonne CP-2 reactor [Abstr. 460 (1953)]. The choice of the possible solutions depends on the applications envisaged.

J. J. PHIPPS

539.172.4

4079. On the temperature rise in thermal reactors after failure of the cooling. R. SCHULTEN AND H. GAUS. *Z. Naturforsch.*, **9a**, No. 12, 1039-43 (Dec., 1954) In German.

The maximum possible temperature rise in the interior of a nuclear reactor when the cooling and control mechanism fail, is deduced. A. O. STANESBY

539.172.4

4080. Temperature measurements in JEEP. A. LUNDBY. *JENER Rep.*, No. 32, 6 + ix pp. (1954).

Preliminary studies have been made of the thermal characteristics of JEEP. The thermal resistance between uranium and aluminium canning has been found to be rather large in the region of operation. Thus at 250 kW (about 2.5 watts/cm² heat flowing through the surface of a central uranium rod) the maximum temperature difference is about 90°C. The

effects of temperature variations on the kinetic behaviour of the reactor have been studied. The temperature coefficients for the uranium and the heavy water have been found to agree with measurements in other laboratories ($\alpha_u = -1.5 \times 10^{-5}$ per deg C, $\alpha_{D_2O} = -25 \times 10^{-5}$ per deg C). A.

539.172.4

4081. Effect of photoneutrons on the transfer function of a heavy-water reactor. A. LUNDBY. *JENER Rep.*, No. 33, 7 + ii pp. (1954).

This is a fuller version of a paper previously published [Abstr. 11427 (1954)].

539.172.4

4082. The Swedish reactor. S. EKLUND. *J. nuclear Energy*, 1, No. 2, 93–100 (Dec., 1954).

A new heavy-water reactor commenced operation in Sweden on July 13, 1954. This paper describes the construction and gives details of the initial operation of this new reactor. A.

539.172.4

4083. f -Calculation in heterogeneous nuclear reactors by matrix formalism. P. SCHMID. *J. nuclear Energy*, 1, No. 2, 101–9 (Dec., 1954).

Using ordinary diffusion theory, the present work gives a universal method for calculating the thermal utilization factor f of a heterogeneous reactor with an elementary cell that contains an arbitrary number of concentric cylindrical shells. Approximations for the exact matrix elements reduce the computation work considerably. An extension of this formalism, which allows for an additional cylindric-shell-shaped cooling medium with moderating properties, is given in the appendix. A.

539.172.4

4084. Measurements of the velocity distribution of the neutrons escaping from a thermal nuclear reactor. J. PELSER. *Physica*, 21, No. 1, 22–8 (Jan., 1955).

Measurements made on the reactor at Kjeller, Norway, are described. The distribution fits very close to a Maxwellian with a temperature of 393°K. A.

ATOM AND MOLECULAR BEAMS . MESONS NEUTRONS 539.18

539.18

4085. On a systemization of heavy mesons and hyperons. J. RAYSKI. Letter in *Nuovo Cimento*, 12, No. 6, 945–7 (Dec., 1954).

An attempt to classify the known elementary particles on the assumption that there is a field corresponding to every irreducible representation of the group of rotations and reflections. P. T. MATTHEWS

539.18

4086. Phenomenological study of the new particles. Λ -Particles and Λ -nuclei. R. GATTO. *Nuovo Cimento* (Ser. 10) 1, No. 3, 372–93 (March, 1955).

Some questions on the new unstable particles are discussed, with the deliberate avoidance of any very specific assumption. The slowness of the decay rates imposes, by semi-qualitative arguments, relevant restrictions. An attempt is made to develop such a viewpoint, and conclusions are drawn about produc-

tion processes, about processes in which the excited hyperon takes part and about processes which occur after the capture of a heavy meson or a hyperon by a nucleus. The important question is to know what other independent assumptions must be added to that of the long mean lives to get a consistent scheme. The Λ^0 -nuclei are moreover analysed from a more phenomenological standpoint. The implications of this analysis on the high spin model of the Λ^0 are discussed. The arguments are not strictly quantitative; however, their possible failure would be in any case an interesting conclusion. The possible composite nature of the new particles is briefly discussed in connection with the rôle of weak interactions and with the possible validity of charge independence at production. Charge independence at decay is not expected to hold and this question is discussed in the case of the θ^0 -meson. A.

539.18

4087. Models of hyperons. H. ENATSU AND C. IHARA. *Nuovo Cimento* (Ser. 10) 1, No. 3, 394–402 (March, 1955).

Methods of mixed fields [Abstr. 8663 (1954)] are extended to the case of hyperons. In order to take into account a new particle (Y -particle) which decays into a Λ -particle and a π -meson, a set of the so-called strong interactions between hyperons and mesons is assumed. Then the Λ -particle self-energy is calculated to the second-order terms through the use of the method of present field theory. Some relations in which the masses of these hyperons and mesons are included are derived from the cancellation of its divergence. It is shown that their masses estimated in terms of the relations are as follows: $Y \sim 2600 m_e$, $\Lambda \sim 2200 m_e$ and the masses of scalar mesons which decay into two π -mesons are $800 m_e - 1500 m_e$. The model presented gives results in qualitative agreement with experiment. A.

539.18

4088. Behavior of neutral particles under charge conjugation. M. GELL-MANN AND A. PAIS. *Phys. Rev.*, 97, No. 5, 1387–9 (March 1, 1955).

Some properties are discussed of the θ^0 , a heavy boson that is known to decay by the process $\theta^0 \rightarrow \pi^+ + \pi^-$. According to certain schemes proposed for the interpretation of hyperons and K -particles, the θ^0 possesses an antiparticle θ^0 distinct from itself. Some theoretical implications of this situation are discussed with special reference to charge conjugation invariance. The application of such invariance in familiar instances is surveyed. It is then shown that, within the framework of the tentative schemes under consideration, the θ^0 must be considered as a "particle mixture" exhibiting two distinct lifetimes, that each lifetime is associated with a different set of decay models and that no more than half of all θ^0 's undergo the familiar decay into two pions. Some experimental consequences of this picture are mentioned. A.

539.18

4089. On a method of determining the residual range of hyperons. G. BARONI, G. CORTINI AND A. MANFREDINI. *Nuovo Cimento* (Ser. 10) 1, No. 3, 473–81 (March, 1955) In Italian.

A method is described for the measurement of the

residual range of particles decaying in flight in nuclear emulsions. The scattering is measured following the conventional constant-sagitta scheme and from a suitable least-squares treatment of the experimental data the residual range value and its standard error are obtained. A.

539.18

4090. Selection rules for meson decays into two bosons imposed by the conservation of angular momentum and parity. B. JAKŠIĆ. *Period math.-phys. astron.* [Zagreb] **9**, No. 1, 27–33 (1954).

A complete list of selection rules obtained on the lines of Abstr. 4601 (1953) for indistinguishable or distinguishable bosons of any spin. W. J. SWIATECKI

539.18

4091. Decay and production of Λ -particles. G. EDER. *Z. Phys.*, **140**, No. 2, 215–20 (1955) In German.

These are calculated by field theory taking the Λ -field (a) as a spinor and (b) as a pseudospinor field. In both cases the probability of decay $\Lambda^0 = p + \pi^-$ is compared with that of a mode of decay involving transfer of momentum and energy to a nucleon without meson emission. The latter mode of decay, which can, of course, only happen when Λ^0 -particles are bound in the nucleus, is found to be 16 times more probable in case (a), while in case (b) it is 85 times more probable. It is suggested that experiments on Λ -decay in nuclei could decide the spinor parity. Production mechanisms are also discussed. Single production being very small, Λ -pair creation by nucleon-nucleon annihilation and by pion-pair annihilation is calculated. Since threshold energies are high, these processes are thought to be unlikely although for high-energy cross-sections of the order of mb are obtained. It is pointed out that interaction by means of τ -meson exchange cannot lead to larger cross-sections since such coupling would also contribute to the free Λ -decay and therefore has to be small. H. MOTZ

539.18

4092. Mean life of decay of muons in the absence of matter. N. N. BISWAS. *Indian J. Phys.*, **28**, No. 9, 431–6 (Sept., 1954).

The possibility of a slow decrease of the mean life of the positive muons with the decrease of Z , as seen from some accurate experiments of recent times, has been utilized to infer that the mean life of free decay of the negatives (in the absence of matter) is about $2.35 \mu\text{sec}$, which is higher than the mean life of the positives ($2.22 \mu\text{sec}$), if the positives are assumed to undergo free decay in the presence of matter. It is argued that the variation of τ_+ with Z , if true, may either be due to the deceleration of the positives by the Coulomb field or the capture of the positives as the Coulomb barrier decreases. The latter process is thought to be more likely. A.

539.18

4093. Measurements of the lifetimes of charged heavy unstable particles. P. R. BARKER, D. M. BINNIE, B. D. HYAMS, R. J. ROUT AND J. SHEPHERD. *Phil. Mag.*, **46**, 307–10 (March, 1955).

A new counter method for measuring the lifetime of unstable mesons is described. Lifetime measurements on 13 charged heavy mesons are reported. It is con-

cluded that if there exists only one heavy meson giving fast decay products, with a lifetime greater than $5 \times 10^{-9} \text{ sec}$, its lifetime is $(11.0^{+4.1}_{-2.4}) \times 10^{-9} \text{ sec}$. No evidence for any longer-lived heavy mesons has been found. A.

539.18

4094. Further evidence for nuclear interaction of a charged hyperon arrested in photographic emulsion. R. H. W. JOHNSTON AND C. O'CEALLAIGH. *Nuovo Cimento (Ser. 10)* **1**, No. 3, 468–72 (March, 1955).

See Abstr. 5993 (1954). A further example is described of the interaction at rest of a particle of protonic mass. The appearance of the interaction is that of a typical σ -star of six branches. The parent particle is ejected from a star of type $23 + 1p$ and comes to rest after a range of 7 mm. Estimates of mass by two independent techniques are in agreement with each other, and are consistent with those of charged hyperons reported by other workers. A.

539.18

4095. Hyperon events in photographic emulsions. M. W. FRIEDLANDER, D. KEEFE AND M. G. K. MENON. *Nuovo Cimento (Ser. 10)* **1**, No. 3, 482–91 (March, 1955).

Details are given of six hyperon events. Two of these decay at rest into protons and give Q -values of $115.8 \pm 1.0 \text{ MeV}$ and $113.5 \pm 1.7 \text{ MeV}$ for the assumed decay scheme: $Y^+ \rightarrow p + \pi^0 + Q$. Three others decay in flight; two give Q -values $115 \pm 7 \text{ MeV}$ and $103 \pm 10.5 \text{ MeV}$ for the decay mode: $Y^\pm \rightarrow n + \pi^\pm + Q$; the third is in agreement with the cascade type of decay: $Y^- \rightarrow \Lambda^0 + \pi^- + Q$ and has a $Q = 59 \pm 11 \text{ MeV}$. The sixth event has been interpreted as the interaction at rest of a negative hyperon; from the parent star of this hyperon there also emerges a K -meson. A.

539.18

4096. Observation of a heavy meson of charged θ type in emulsions exposed to cosmic rays. J. CRUSSARD, T. F. HOANG AND L. LEPRINCE-RINGUET. *C.R. Acad. Sci. [Paris]* **240**, No. 3, 261–4 (Jan. 17, 1955) In French.

A κ -meson at rest gives a secondary which can be identified as a π -meson. The energy of the latter suggests a disintegration $\theta^\pm \rightarrow \pi^\pm + \pi^0$ with Q -value $(216 \pm 9) \text{ MeV}$, which is close to the known Q of $(214 \pm 5) \text{ MeV}$ for $\theta^0 \rightarrow \pi^+ + \pi^-$. J. S. BELL

539.18

4097. Statistical theory of multiple meson production. R. H. MILBURN. *Rev. mod. Phys.*, **27**, No. 1, 1–14 (Jan., 1955).

The Fermi statistical theory of multiple meson production is examined, and its application to medium-energy pion-nucleon and nucleon-nucleon collisions is discussed. Various approximate calculational procedures are described and their results compared critically. It is found, by the use of a precise integration procedure, that a rigorous relativistic inclusion of the meson rest mass is necessary if one is to draw accurate conclusions from the postulates of the theory. The consequences of isotopic spin conservation are described and tables are given for the expected distribution of charged products from both pion-nucleon and nucleon-nucleon collisions. The theory is applied to the case of pion-nucleon collisions at 1.4 BeV , and

is found to predict only poorly the tentative results of recent experiments. The failure of the theory to predict nucleon-nucleon collisions is also described, and possible modifications and improvements are discussed.

A.

539.18

4098. Production of mesons of energies near to threshold. A. B. MIGDAL. *Zh. éksp. teor. Fiz.*, **28**, No. 1, 10–12 (1955) In Russian.

The region of maximum probability of meson production in nucleon-nucleon collisions, in which the two nucleons are left with low relative momentum, is investigated. Formulae are obtained for the case where the two nucleons are left in a bound state (deuteron), a virtual state or in the continuum.

G. E. BROWN

539.18

4099. Associated production of a τ -meson and a charged hyperon. K. GOTSTEIN. *Nuovo Cimento (Ser. 10)* **1**, No. 2, 284–90 (Feb., 1955).

In a stack of stripped emulsions an example of associated production of a positively charged τ -meson and of a hyperon decaying in flight into a charged L -meson was observed. The mass of the hyperon is found to be $2374^{+29}_{-37} m_e$ assuming the decay scheme $Y^\pm \rightarrow \pi^\pm + n + Q$. For the τ -meson one obtains from range measurements $m_\tau = 963 \pm 0.5 m_e$, all three secondaries coming to rest in the emulsion. A possible reason is suggested why some authors might have slightly overestimated the mass of their τ -mesons.

A.

539.18

4100. Charge and isotopic-spin conservation in multiple meson production. Y. YEIVIN. *Phys. Rev.*, **97**, No. 4, 1084–5 (Feb. 15, 1955).

General formulae are derived for the corrections to Fermi's cross-sections, which follow from the conservation of (a) charge, or (b) charge plus isotopic spin. The possible identity of some of the particles which appear after a nucleon-nucleon collision is also taken into account. It turns out that there is only a slight difference between results calculated under assumption (a) or (b).

A.

539.18

4101. Production of neutral V -events by cosmotron neutrons. R. M. WALKER, R. S. PRESTON, E. C. FOWLER AND H. L. KRAYBILL. *Phys. Rev.*, **97**, No. 4, 1086–92 (Feb. 15, 1955).

Approximately 2000 cloud chamber pictures have been taken in the forward beam of neutrons produced by high-energy protons striking a beryllium target in the cosmotron. Nine V -events interpreted as the decay of a neutral particle produced in a one-inch lead plate in the cloud chamber, were observed. The neutron flux is estimated, from stars observed in the argon gas of the chamber, to be 140 per picture. An upper limit to the cross-section for Λ^0 -production of 3 millibarns per lead nucleus is deduced for the meson-producing neutrons.

A.

539.18 : 530.145

Fermi theory of multiple production of particles in nucleon collisions. See Abstr. 3456

539.181

4102. Scattering of high velocity neutral particles. V. Neon-neon. I. AMDUR AND E. A. MASON. *J. chem. Phys.*, **23**, No. 3, 415–16 (March, 1955).

For Pt IV, see Abstr. 9637 (1954). Total collision cross-sections have been measured for neon atoms with energies between 500 and 2100 eV scattered in room-temperature neon. The experimental results have been treated to obtain potential energy information for the interaction of two neon atoms. The analytical relation, which may be represented by $V(r) = 5.00 \times 10^{-10}/r^{9.99}$ erg for r between $1.76 \text{ \AA}$ and $2.13 \text{ \AA}$, is consistent with the potential, valid at larger separation distances, which has been derived from measurements of gaseous compressibility, viscosity and crystal properties.

A.

539.185

4103. On the diffusion of decaying particles. L. GOLD. *J. appl. Phys.*, **26**, No. 2, 233–5 (Feb., 1955).

The probability of neutron absorption on a spherical surface for a radial source in a medium for which the particle has prescribed lifetime and rate of diffusion is calculated. This helps to illuminate the more intricate, related problem for a charged particle diffusing in the presence of a radial inverse-square electric field to the extent that an explicit relation for the relative absorption probabilities that accompany changes in the direction of the drift field is secured. An asymptotic solution for the absorption probability is also provided which in first-order approximation may be applied in the range of interest for transistors.

A.

539.185 : 537.534.74

Theory of polarization of nucleons scattered elastically by nuclei. See Abstr. 3832

539.185

4104. Multiplicity of neutrons from the spontaneous fission of californium-252. D. A. HICKS, J. ISE, JR AND R. V. PYLE. Letter in *Phys. Rev.*, **97**, No. 2, 564–5 (Jan. 15, 1955).

This was measured using a fission chamber immersed in a Cd-loaded liquid scintillator and recording photographically the delayed coincidences between fission pulses and neutron-capture γ -ray pulses in the liquid scintillator; the neutron detection efficiency was $\sim 46\%$. The experimental measurements agree well with a binomial distribution with $n = 6$ or 7, but the form of the true distribution cannot be definitely stated.

A. O. STANESBY

539.185.08 : 537.542

4105. Detection of thermal neutrons by borazole-filled proportional counters. H. C. HAMERS, J. BLOK, C. C. JONKER, A. E. DE VRIES, H. JANSZ AND J. KISTEMAKER. Letter in *Physica*, **20**, No. 11, 1138–40 (Nov., 1954).

A description is given of the preparation of borazole ($B_3N_3H_6$) condensed with liquid nitrogen from heated $LiBH_4$, NH_4Cl and Pyrex glass powder, avoiding moisture, oxygen or grease. The borazole-filled counter was shown to be three times as efficient relative to a similar filling of BF_3 , although the maximum pulse-height in BF_3 is about four times larger due to the greater gas-amplification-factor (5 : 1) observed in the latter gas. It was also shown that the primary ionization in borazole is larger than in BF_3 .

D. R. CHICK

539.185.08 : 537.542

Fission chambers for neutron detection. See Abstr. 3840

539.185.7

4106. The thermal neutron absorption cross-section of boron. A. GREEN, D. J. LITTLER, E. E. LOCKETT, V. G. SMALL, A. H. SPURWAY AND E. BOWELL. *J. nuclear Energy*, **1**, No. 2, 144-9 (Dec., 1954).

This paper summarized measurements of the thermal neutron absorption cross-section of boron made at Harwell, in Sweden and in the U.S.A. It also describes a new measurement made at Harwell. The agreement between the Harwell and Swedish values is good, but there is still some disagreement between these and the latest American values. A.

539.185.7

4107. Effect of asymmetric oxygen scattering on the slowing-down length of neutrons in water. H. C. VOLKIN. Letter in *J. appl. Phys.*, **26**, No. 1, 127-8 (Jan., 1955).

The author's previous calculations [Abstr. 7964 (1953)] are extended by taking into account the deviation from spherical symmetry of the elastic scattering by non-hydrogen nuclei. J. HUGHES

539.185.7

4108. Neutron attenuation measurements in heavy and light water at energies between 109 and 169 MeV. R. ALPHONCE, A. JOHANSSON, A. E. TAYLOR AND G. TIBELL. *Phil. Mag.*, **46**, 295-9 (March, 1955).

The difference between the total cross-section of deuterium and hydrogen has been obtained at effective energies of 109, 117, 132, 149 and 169 MeV from attenuation measurements on light and heavy water. Using published values of the hydrogen cross-section, the oxygen total cross-section was also obtained at these energies. A.

539.185.7 : 536.48

4109. Transmission of slow neutrons by liquid helium. H. S. SOMMERS, JR, J. G. DASH AND L. GOLDSTEIN. *Phys. Rev.*, **97**, No. 4, 855-62 (Feb. 15, 1955).

The total scattering cross-section of liquid helium was determined for neutrons of wavelengths between 3 and 16 angstroms and at six helium temperatures between 1.25 and 4.6 K. The neutrons were obtained from the thermal beam of a reactor and were monochromatized by a low-resolution velocity selector. The total scattering cross-section decreases with temperature at all wavelengths studied. At the shortest wavelengths the cross-section approximates the free atom value; it exhibits a rapid drop with increasing wavelength. For the 4.6° liquid it passes through a shallow minimum at about 10 Å. At lower helium temperatures, the fall from the free atom cross-section is steeper; the existence of a minimum has not been established. The results are discussed qualitatively on the basis of several models of liquid helium. The only one predicting the overall features of the change of cross-section with wavelength and temperature is the solid model. A.

539.185.7 : 539.172.4

4110. Review of the measurements of the resonance absorption of neutrons by uranium in bulk. E. CREUTZ,

H. JUPNIK, T. SNYDER AND E. P. WIGNER. *J. appl. Phys.*, **26**, No. 3, 257-9 (March, 1955).

This and the three following papers describe some of the early experimental investigations leading to the nuclear reactor, and have not hitherto been publicly available.

539.185.7 : 539.172.4

4111. Resonance absorption of neutrons by spheres. E. P. WIGNER, E. CREUTZ, H. JUPNIK AND T. SNYDER. *J. appl. Phys.*, **26**, No. 3, 260-70 (March, 1955).

See preceding abstract. By concentrating uranium into lumps, one can decrease its resonance absorption as compared with the resonance absorption of the same amount of uranium spread out uniformly in a moderator. It is shown here that this decrease is caused principally, not by the diminished over-all density of the neutrons at the lump, but by their changed energy distribution. This shows deep minima at the resonance lines, i.e. where the uranium absorbs most strongly. The considerations here presented show that the decrease in absorption is largest for the low energy resonances of U^{238} which are responsible for the bulk of the absorption in the case of uniform distribution. As a result, the resonance absorption of uranium lumps extends over a very large energy region—up to about 5000 eV. It can be decomposed, approximately, into two parts: the mass absorption, proportional to the number of U^{238} atoms present; and a surface absorption, proportional to the surface of the lump. The total decrease of the resonance absorption produced by lumping (the "advantage factor" of lumping) can be estimated to reach, under favourable conditions, a value as high as 20. A.

539.185.7 : 539.172.4

4112. Effect of geometry on resonance absorption of neutrons by uranium. E. CREUTZ, H. JUPNIK, T. SNYDER AND E. P. WIGNER. *J. appl. Phys.*, **26**, No. 3, 271-5 (March, 1955).

See Abstr. 4110 (1955). The total resonance absorption of neutrons by spheres of uranium and uranium oxide imbedded in graphite and bombarded with essentially a dE/E spectrum is found to be given by $1/\alpha = c[1 + (\kappa/\rho R)]$ where α is the advantage factor, that is, the ratio of absorption of uranium when distributed uniformly throughout graphite to the absorption when it is lumped in a sphere. R is the radius of the sphere and ρ is its density. c and ρ were measured in various parts of a large graphite block exposed to cyclotron neutrons from the reaction $Li(p,n)$. Values of c and ρ , respectively, are 0.051 and 5.1 g/cm³ for U_3O_8 . In a newer notation, $A = 10.9$ barn and $\mu = 1.95$ g/cm². A.

539.185.7 : 539.172.4

4113. Effect of temperature on total resonance absorption of neutrons by spheres of uranium oxide. E. CREUTZ, H. JUPNIK AND E. P. WIGNER. *J. appl. Phys.*, **26**, No. 3, 276-9 (March, 1955).

See Abstr. 4110 (1955). In the expression $1/\alpha = c[1 + (\kappa/\rho R)]$ for the advantage (α) of decreased resonance absorption of uranium in a dE/E neutron spectrum brought about by lumping UO_2 into spheres, the temperature dependence of c is measured and κ is measured also. ρ is the density of UO_2 in g/cm³; R the radius of the sphere in cm. In the range

20° to 1000°C, $\Delta c/\Delta T$ averages 1.8×10^{-6} per deg c and is positive as expected. This temperature dependence decreases by about a factor of three from the lowest to the highest measured temperatures. κ is 5.06 g/cm³ leading to a value of μ in the expression $[\sigma(E)dE/E]_{\text{eff}} = A[1 + \mu S/M^{-1}]$ of 1.69 g/cm². $\Delta A/\Delta T$ is 4×10^{-4} barn/deg c. A.

STRUCTURE OF SOLIDS 539.2

539.213.1

4114. The structure of amorphous materials. M. L. HUGGINS. *J. phys. Chem.*, **58**, No. 12, 1141-6 (Dec., 1955).

A theory is presented, according to which various extensive properties (e.g. the volume) of amorphous materials can be computed additively from contributions characteristic of the types of "strucon" present, a strucon consisting of an atom (or group of atoms or molecule) surrounded by close neighbours in a given way. If the possible types of strucon differ sufficiently in stability, the number of such types present in appreciable quantities in a sample at equilibrium is small. If it is the minimum number required to give the correct over-all composition, the sets of strucon types present change as suddenly as the composition changes. The property-composition curve then consists of a series of straight-line segments, with sharp breaks between them. Detailed consideration is given to the volumes (and densities) of two-component silicate glasses, especially those in the Na₂O-SiO₂ system. Reasonable sets of strucon types account quantitatively for the locations of the observed breaks. In some composition ranges, definite conclusions can be drawn regarding the strucon types present, their relative numbers and their individual contributions to the total volume. In other composition ranges, the possibilities are greatly limited, but alternative interpretations remain. A.

539.217

4115. Mechanism of intermetallic diffusion. L. SLIFKIN AND C. T. TOMIZUKA. Letter in *Phys. Rev.*, **97**, No. 3, 836-7 (Feb. 1, 1955).

It is pointed out that in ordered alloys in which every atom is surrounded only by atoms of the other kind, it is possible to distinguish between vacancy, interstitial or direct interchange mechanisms by measuring separately the diffusion coefficients of the two components. Tracer experiments on β -brass and on InSb are being undertaken. W. M. LOMER

539.217

4116. Role of partition coefficient in permeability of surface layers with low diffusion coefficient. G. R. LESTER. *Brit. J. appl. Phys.*, **6**, No. 3, 82-3 (March, 1955).

Diffusion through a surface film into an underlying layer is examined using Laplace transformation. An important characteristic of the process is the rate at which equilibrium concentrations are attained and in certain cases this is simply related to the diffusion coefficient of the film and the partition coefficient at the interface. A.

539.219

4117. On the precipitation process in aluminium-zinc-magnesium alloys. I. Al-Al₂Zn₃Mg₃ system. K. HIRANO AND Y. TAKAGI. *J. Phys. Soc. Japan*, **10**, No. 3, 187-92 (March, 1955).

When aluminium-rich Al-Zn-Mg alloy containing 8 weight % zinc and 4 weight % magnesium is quenched from 450°C to room temperature, a super-saturated solid solution is obtained, the breakdown of which on subsequent annealing at various temperatures has been studied by means of calorimetric and electrical resistance measurements and of X-ray photographs. The existing data have been incorporated with new data to clarify the mechanism of precipitation. The existence of two separate processes has been confirmed, that is, "low-temperature ageing," which is a stage of the formation of the Guinier-Preston zone and "high-temperature ageing," which involves the formation of a coherent precipitate and its transformation to an incoherent precipitate. This precipitation sequence is similar to those in the Al-Cu as well as in the Al-Ag binary alloys. A.

539.219

4118. Precipitation from solid solution of lead in magnesium. K. HIRANO, H. MANIWA AND Y. TAKAGI. *J. Phys. Soc. Japan*, **10**, No. 3, 193-7 (March, 1955).

The mechanism of precipitation from super-saturated solid solutions of lead in magnesium has been studied by means of calorimetric and electrical resistance measurements and of X-ray photographs with quenched and annealed alloys of various lead concentrations. The results reveal that the ageing process is constituted from two discrete reactions. The first is the change in the matrix solid solution without decrease of the solute concentration, which corresponds to the formation of a complex or the Guinier-Preston zone, and the second is the precipitation of the Mg₂Pb phase. It was concluded that the first is not preparatory to the second. The upper-limit temperatures of the existence region of the complex were determined for various solute concentrations and shown in the phase diagram. A.

539.22 : 538.566

4119. The detection of anisotropy in opaque, non-metallic materials. A. DIETZEL AND E. DEEG. Note in *Naturwissenschaften*, **42**, No. 1, 11 (1955) In German.

Preliminary note saying that structural anisotropy in certain materials (such as brick, pumice-stone and gypsum) has been investigated by detecting the birefringence of 3 cm waves. A piece of stressed glass was used as the analyser. R. O. DAVIES

539.234 : 548.5

4120. The growth of thin films. G. CARIO AND J. H. KALLWEIT. *Z. Phys.*, **140**, No. 1, 47-56 (1955) In German.

An investigation of the growth mechanism of thin films and an interpretation on the basis of the adsorption theories of Frenkel [*Z. Phys.*, **26**, No. 2, 117-38 (1924); *Kinetic Theory of Liquids*, Oxford (1947)]. The material used was mainly evaporated gold. The films were examined with the electron microscope and the transparency to light was also measured, for films of different thicknesses and for a variety of wave-

lengths. [The legends of Figs. 10 and 11 appear to have been transposed.]

J. IBALL

539.26

4121. Note on the possibility of determining the degree of polymerization of crystalline materials by roentgenographical methods. K. R. ANDRESS AND K. FISCHER. Note in *Naturwissenschaften*, **42**, No. 1, 13 (1955) In German.

539.26 : 539.219

4122. An X-ray structural study of (Ba,Pb)TiO₃ solid solutions. E. G. FESENKO AND A. G. SLABCHENKO. *Zh. tekhn. Fiz.*, **24**, No. 7, 1288-90 (1954) In Russian.

From X-ray powder photographs the cell dimensions of solid solutions of BaTiO₃ and PbTiO₃ were measured at intervals of 10% in composition. *c/a* increases steadily from 1.01 to 1.07 as the proportion of PbTiO₃ increases. The cell dimensions of (BaTiO₃ + 8% PbTiO₃) were measured at temperatures between 20° and 150°, giving curves very similar to those of pure BaTiO₃. The transition points of the solid solution and the pure BaTiO₃ were 145° and 125° respectively.

A. L. MACKAY

539.26 : 548.736.1

4123. Relation between the X-ray diffraction diagram and the micrographic appearance of a polygonized crystal of aluminium. C. DE BEAULIEU. *C.R. Acad. Sci. [Paris]* **240**, No. 5, 522-4 (Jan. 31, 1955) In French.

Crystals produced by secondary recrystallization of pure aluminium polygonize after prolonged annealing. The relative disorientation of the blocks making up the crystal is shown to differ according to the crystallographic planes from which the X-rays are reflected.

A. E. DE BARR

539.27

4124. Preparation of specimens for the electron diffraction camera. P. R. ROWLAND. *Vacuum*, **3**, No. 2, 136-50 (April, 1953; publ. Dec., 1954).

The method of the article is to illustrate by examples the types of technique used and the precautions which must be observed. These, together with the literature references, are designed to enable suitable methods to be devised for any specific case. The subjects are dealt with under the following headings. Transmission: making collodion films; powders, suspensions and deposits from solution; rubber, oils, greases; metal films; oxide films and vitreous substances. Reflection: powders, smokes, crystals, condensed vapours; oils, greases; compact solids, especially single crystals; polycrystalline solids. There are also sections on reactions carried out in the camera, and on precautions. 31 refs.

A.

539.27

4125. Replica studies of bulk clays. J. J. COMER AND J. W. TURLEY. *J. appl. Phys.*, **26**, No. 3, 346-50 (March, 1955).

The electron microscope examination of the surfaces of bulk clays by replica techniques is difficult because of the propensity of the clays and the necessity of using hydrofluoric acid to dissolve the clay from the replicas. The surfaces of some bulk endellite clays were examined by means of collodion, silica, and preshadowed replicas. Collodion and two-step

silica replicas were unreliable and difficult to use because of penetration of the collodion or plastic into the pores of the clay. Collodion strippings were of some value in removing layers of clay particles from the surface for direct examination in the microscope. Best results were obtained with the preshadowing technique which employed a shadowing layer of platinum backed by a layer of evaporated carbon or by Parlodion. Micrographs of replicas prepared by the latter technique show the surface of a highly porous endellite clay to consist of tubes in various orientations.

A.

ELASTICITY . STRENGTH . RHEOLOGY

539.3/.8

539.31

4126. On the realistic stress space of solids. LIU SHU-I. *Acta Sci. Sinica*, **3**, No. 2, 187-203 (June, 1954).

By realistic stress space is meant the bounded portion of stress space containing all stress states that can actually occur in matter. It reflects the main mechanical characteristics of matter. As the state of aggregation becomes more condensed, the realistic stress space expands to three dimensions when reaching solid state. There exists no definite concept regarding the complete geometric structure of the realistic stress space of solids. The purpose of this paper is to formulate a theory on the concerned aspects by combining four theories: the author's theory on isothermal rupture, von Mises-Hencky's hypothesis on plastic deformation, Pavlov's theory on mutual relation between deforming and deformed bodies and Nadai's theory on strain-hardening. According to the formulated theory, the realistic stress space of solids is bell-shaped, closed and symmetrical with respect to the hydrostatic axis with six limiting surfaces and one dividing plane. When the processes of deformation are considered in connection with this space, the main mechanical characteristics of solids immediately becomes apparent, and the predictions agree with the well-known facts and concepts on the mechanical properties of solids. The processes of deformation are classified according to the relation between deformation processes and the bell stress space.

A.

539.31 : 534.372

4127. The theory of the internal damping of oscillating solids. K. VOELZ. *Abhandl. Braunsch. Wiss. Gesell.*, **6**, 126-65 (1954) In German.

Surveys the theories existing today for damping of oscillating solids. The oldest are the purely formal representations of solids by Maxwell or Kelvin elements, today extended to a point where the solid is considered as a parallel wiring of such elements with a finite or infinite number of different relaxation times. From a physical point of view a distinction must be made between damping effects depending on the shape of the oscillating solids like damping by macroscopic heat currents and such effects due to the oscillating matter alone. For these latter Prandtl has elaborated a theory starting from the fact that

matter consists of molecules; this theory has been extended and made clearer from a mathematical point of view by Eyring. It includes as special cases damping independent of frequency and the true relaxation phenomena of which the most important are discussed.

A.

539.32 : 531.53

4128. High-vacuum torsion pendulum for anelastic studies. S. WEINIG. Note in *Rev. sci. Instrum.*, **26**, No. 1, 91-2 (Jan., 1955).

539.32 : 541.182.5

4129. An apparatus for measuring the elastic properties of gels. L. J. HASTEWELL AND R. ROSCOE. *J. sci. Instrum.*, **32**, No. 3, 96-9 (March, 1955).

A simple apparatus devised by McDowell and Usher (1931) for the demonstration of elastic properties in colloidal suspensions can be adapted to give numerical results. It consists essentially of a float which is placed coaxially in a cylindrical vessel containing the suspension. A pair of vanes are carried by a spindle attached to the float so that the latter can be set in rotation by directing jets of air on to the vanes. In the case of gels, the subsequent rotation of the float is usually oscillatory, and the dynamic rigidity and dynamic viscosity can be calculated from the frequency and decrement of the oscillations. The apparatus has to be calibrated with a liquid of known viscosity having the same density as the gel.

A.

539.32 : 621.365.55

4130. A dielectric heating and test unit for the study of sand properties at elevated temperatures. R. REW AND R. G. GODDING. *J. sci. Instrum.*, **32**, No. 3, 93-5 (March, 1955).

To obtain rapid and uniform heating of sand specimens, a dielectric heater operating at 100 Mc/s has been built. This is used in conjunction with a mechanical testing apparatus that records the stress/strain relation on a photographic plate and also gives an indication of the brittleness of fracture of the specimen.

A.

539.37

4131. Attenuation of elastic waves in lead at high temperatures. P. G. BORDONI AND M. NUOVO. *Ricerca sci.*, **24**, No. 12, 2614-22 (Dec., 1954) In Italian.

This was measured in pure lead, for frequencies between 10 and 30 kc/s, at temperatures between 300 and 600°K, in order to extend the range of previous measurements. The attenuation was found to increase with temperature, whilst it decreases when frequency is raised. These results have been explained from a theoretical standpoint, showing their relation with creep phenomena, taking place under constant stress.

A.

539.374 : 534.32

Ultrasonic attenuation in zinc single crystals while undergoing plastic deformation. See Abstr. 3518

539.374 : 535.55

4132. Application of micro-photoelasticity to the study of plastic deformation. M. BONVALET. *C.R. Acad. Sci. [Paris]* **240**, No. 2, 157-8 (Jan. 10, 1955) In French.

Fleury and Zandman [Abstr. 6539 (1954)] have

proposed a photoelastic method in which the material under test is covered with an ethoxy resin and then stressed. The resin is deformed in precisely the same way as the material and exhibits double refraction. Observation is carried out with a microscope and the measurements give information on the state of stress in the material. The present note gives a brief description of the method and of the results obtained when pieces of steel and duralumin with circular holes in them are stressed. Differences between the principal extensions of the order of 2×10^{-5} can be detected.

H. G. JERRARD

539.389.3

4133. Relaxation-time distribution functions and the Kramers-Kronig relations. M. K. BRACHMAN AND J. R. MACDONALD. *Physica*, **20**, No. 12, 1266-70 (Dec., 1954).

Gives a general proof that the real and imaginary parts of a function representing a physically realizable network, with a distribution of relaxation times, satisfy the Kramers-Kronig relations. It is shown that a simple relation between the Mellin transforms of the real and imaginary parts, is sufficient for the validity of the relations, and in consequence the conditions stated as necessary by Bode are too stringent.

G. D. SIMS

539.434

4134. An evaluation of the recovery theory of creep. H. H. BLEAKNEY. *Canad. J. Technol.*, **33**, No. 1, 56-66 (Jan., 1955).

Evidence is presented to show that the phenomenon of creep-rupture embrittlement is not necessarily inconsistent with the recovery theory; that the equi-cohesive temperature concept may be without validity; and that Ké's conclusions are not substantiated by the evidence. It is suggested that the opposing influences of strain-hardening and thermal softening, modified by factors introduced by metallurgical instabilities, are the fundamental verities of creep.

A.

539.434 : 548.7

4135. Temperature dependent creep in zinc crystals. D. O. THOMPSON. *J. appl. Phys.*, **26**, No. 3, 280-5 (March, 1955).

Tensile creep measurements beginning in a tensile strain region of about 10^{-6} have been made upon a set of seven single crystals of zinc of 99.99+ % purity. Measurements were made both by means of electrical resistance strain gauges and an optical lever system. Some of the measurements made in the latter apparatus lasted 100 hr or more, and in both systems, measurements were made at several temperatures. The creep results obtained can be best described by the single empirical relation $\eta = bt^m$ in which η is the shear strain, t is the time after completion of the application of stress to the crystal, and b and m are constants for a given creep test under given experimental conditions. It is found that b increases with the stress but does not vary greatly with temperature. The values of m are practically independent of stress but vary with temperature, and appear to fit best the equation, $m = m_0 \exp(-To/T)$ in the temperature interval investigated. For these crystals $To = 1580^\circ K$, $m_0 = 120$,

and the temperature at which $m = 1$ is 58°C . Values of $m > 1$ are interesting in dislocation theory. A.

539.434 : 548.7

4136. Creep of zinc crystals. E. P. T. TYNDALL, R. A. ARTMAN, C. A. WERT AND R. EISNER. *J. appl. Phys.*, **26**, No. 3, 286–94 (March, 1955).

The plastic extension of zinc crystals in the region just beyond the elastic limit is found to obey the empirical law, $\eta = bt^m$ in which η is the resolved shear strain, t is the time, m is a constant with a value close to 0.5 for initially unstrained crystals, and b is dependent on the resolved shear stress. Application of a theory due to Koehler shows that b should be related to stress (σ) in such a way that a plot of $\ln(mb\sigma^2/\Delta\sigma)$ against $1/\sigma$ should be a straight line of slope $-cG$. In this, $\Delta\sigma$ is the stress increment from one creep curve to the next, G is the shear modulus, and c is the concentration of anchor points which determines the lengths of segments of dislocation lines which generate according to the Frank–Read mechanism. The experiments are in fair agreement with this theory and values of c obtained are roughly equal to the concentrations of metallic impurities. The small amount of dissolved gases appears to play no significant part in the creep process. A.

539.434 : 551.311.123

4137. The creep of polycrystalline ice. J. W. GLEN. *Proc. Roy. Soc. A*, **228**, 519–38 (March 22, 1955).

Polycrystalline blocks of ice have been tested under compressive stresses in the range from 1 to 10 bars at temperatures from -13°C to the melting-point. Under these conditions ice creeps in a manner similar to that shown by metals at high temperatures; there is a transient creep component and also a continuing or quasi-viscous component. The relation between the minimum observed flow rate $\dot{\epsilon}$, the applied stress σ and the absolute temperature T is $\dot{\epsilon} = B \exp(-Q/RT)\sigma^n$, where R is the gas constant, and B , n and Q are constants; the value of n is about 3.2, that of Q is 32 kcal/mole, and that of B is 7×10^{24} if the stress is measured in bars and the strain rate in years $^{-1}$. At the higher stresses a third, accelerating stage of creep was observed; on the basis of the appearance and behaviour of sections cut from the specimens, this acceleration was attributed to recrystallization. The effect of changing the load during a test has also been studied; for large reductions creep recovery was observed. The results of these tests are discussed in connection with previous work on metals and ice, and also with measurements of glacier flow. A.

539.62

4138. Noiseless dry surface friction of metals at low speeds. N. F. KUNIN AND G. D. LOMAKIN. *Zh. tekhn. Fiz.*, **24**, No. 8, 1361–6 (1954) In Russian.

A distinction is made between noiseless, squeaking and “stick-slip” friction. It is assumed that for noiseless friction the variation of friction with speed is due primarily to variation in area of contact with the effective lifetime of the individual microjunctions. This leads to a relation between μ at any speed v of the form $\mu = \mu_0(1 - Ke^{-8/v})$. A similar dependence of static friction on time of preloading is derived. Both relationships are found to agree with experiment. A direct connection is established between parameters characteristic of friction and those characteristic of the behaviour of metals during plastic compression. Friction results for tin sliding on iron are successfully correlated with data on the dynamic yield stress of lead under compression. J. A. SPINK

539.62

4139. The relation between static and kinetic friction. N. F. KUNIN AND G. D. LOMAKIN. *Zh. tekhn. Fiz.*, **24**, No. 8, 1367–70 (1954) In Russian.

Sudden slip occurs between sliding surfaces when there is a simultaneous rupture of all the individual microjunctions, whereas in kinetic friction there is a continuous formation and shearing of the junctions. Increased times of preloading increase the real area of contact. Conversely, for short times of preloading there is less relaxation of the plastic work hardening. These factors are used to explain the rapid change in frictional force during transition from static to kinetic friction. J. A. SPINK

539.622

4140. Elastic work involved in rolling a sphere on another surface. D. TABOR. *Brit. J. appl. Phys.*, **6**, No. 3, 79–81 (March, 1955).

A theoretical calculation is made of the elastic work involved in rolling a ball over another surface. The analysis is based on Hertz's equation for the static deformation of spherical surfaces since it is assumed that the additional stresses produced by rolling are small compared with those produced by the normal load. The results show that the work involved in rolling a sphere on a flat surface is substantially the same as that involved in rolling a sphere in a groove of almost the same curvature as the sphere. This conclusion is in line with certain previous work by the author on the rolling friction of steel spheres on rubber. A.

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM.

CHEMICAL REACTIONS 541.11/12

541.124

4141. The elementary process of the organic heterolytic reaction in the liquid phase. C. PRÉVOST. *Cahiers de Phys.*, No. 52, 58–68 (Nov., 1954) In French.

A general survey is given of such reaction mechanisms. The reactions are usually bimolecular, rarely

of higher order, but sometimes no order can be assigned, though even in these cases two molecules are actually concerned in the reaction. Most organic reactions are of ionic or heterolytic character, as ions or molecular groups either contain a lone pair of electrons or a deficiency of electrons by which other groups can be attached. Thus reactions can be nucleophilic or electrophilic. Various examples are discussed. A. J. TAYLOR

541.124

4142. Thermal stability of *ortho*-, *para*-, and *meta*-xylyl radicals and the formation of quinodimethanes. J. B. FARMER, D. G. H. MARSDEN AND F. P. LOSSING. Letter in *J. chem. Phys.*, **23**, No. 1, 403-4 (*Jan.*, 1955).

Mass spectrometer measurements show that the relative stability of the *meta*-xylyl radical is much greater than that of the *ortho*- and *para*-forms and indicate that quinodimethanes are formed as products of the thermal decomposition of the latter two.

W. GOOD

541.126

4143. Detonation waves and the principle of minimum entropy production. G. H. DUFFEY. Letter in *J. chem. Phys.*, **23**, No. 2, 401 (*Feb.*, 1955).

The Chapman-Jouguet condition can be found by showing that the entropy change per gram of explosive reacting is a minimum and that this condition corresponds to the minimum detonation velocity consistent with the constraints.

C. TURNER

541.126

4144. Mechanism of detonation. M. A. COOK. Letter in *J. chem. Phys.*, **23**, No. 2, 409-10 (*Feb.*, 1955).

A preliminary theoretical treatment of experimental results to be published and discussed later.

W. GOOD

541.126.2

4145. The ignition mechanism in the Diesel engine. I. K. TERAOKA. *J. Phys. Soc. Japan*, **10**, No. 2, 154-60 (*Feb.*, 1955) In German.

The fluctuating nature of the ignition delay was analysed statistically in relation to fuel diffusion phenomenon.

A.

541.127

4146. Fine structure of olefine deuteration. T. KEIL. Letter in *J. chem. Phys.*, **23**, No. 1, 210-11 (*Jan.*, 1955).

Although other authors explain the fact that a random distribution law holds among the observed relative amounts of deuterio-butanenes from *cis*-2-butene deuteration by the introduction of a new reaction mechanism, it is shown here that the theory of the associative mechanism [Abstr. 6071 (1954)] gives a satisfactory account of the phenomena observed. Propylene hydrogenation is taken as example; the reaction mechanism is explained and the conclusions drawn agree with experiment.

A. J. TAYLOR

541.127 : 539.16.08

4147. Studies on solid state reactions with radio-tracers. R. LINDNER. *J. chem. Phys.*, **23**, No. 2, 410-11 (*Feb.*, 1955).

Self diffusion was measured with radioactive tracers in a large number of systems. The results are tabulated. Transfer numbers in solid oxides and silicates were measured. Values ranging from 10^{-3} to 10^{-2} were found. The first stage in reactions between compressed powder mixtures was investigated. A linear reaction rate was observed. The diffusion stage of solid-state reactions was examined and compared with calculated reaction rates. Wagner's theory was tested and supported in the cases of zinc oxidation and the formation of zinc-iron spinel, but not in the case of lead oxidation and the formation of silicates.

A. J. TAYLOR

ELECTROCHEMISTRY 541.13

541.13 : 537.36 : 541.18.045

4148. Electrophoretic "line spectra." A. KOLIN. Letter in *J. chem. Phys.*, **23**, No. 2, 407-8 (*Feb.*, 1955).

The method used for the separation of proteins [Abstr. 588 (1955)] is here extended to non-ampholytic ions which can thus also be concentrated in the form of thin laminae and separated. A photograph shows the separation effected in ten minutes of a mixture of the dyes basic fuchsin, chrome hematoxylin, bromthymol blue and bromphenol blue.

W. GOOD

541.136 : 537.32

4149. Thermoelectric phenomena in galvanic cells. H. HOLTAN, JR. *Proc. K. Ned. Akad. Wetensch. B*, **57**, No. 5, 592-5 (*Nov.-Dec.*, 1954).

The expression for the potential difference of galvanic cells containing also temperature gradients is derived. It is shown that there is a simple relationship between this potential difference and the potential differences of the corresponding isothermal cell and the corresponding pure thermocells (Soret effects hindered). These new relations may easily be tested experimentally.

A.

PHOTOCHEMISTRY . RADIATION
CHEMISTRY 541.14/.15

541.15

4150. Irradiation of ferrous ammonium sulfate solutions: energy absorption and ionization calculations for cobalt-60 and betatron radiation. D. V. CORMACK, R. W. HUMMEL, H. E. JOHNS AND J. W. T. SPINKS. *J. chem. Phys.*, **23**, No. 1, 162-4 (*Jan.*, 1955).

G values have been recalculated taking into account wall effects which were neglected in Abstr. 3960 (1954).

A.

DISPERSIONS . COLLOIDS
ADSORPTION 541.18

541.18.047 : 534.21

Coagulating mechanism of acoustic current. See Abstr. 3503

541.182.025

4151. On the break-down of thixotropic materials. S.-E. DAHLGREN. *Chalmers Tekn. Högsk. Handl.*, No. 159, 18 pp. (1955).

Based on the experimental work carried out by Green and Weltmann an analytical treatment of the thixotropic breakdown has been made. To fully characterize a thixotropic Bingham body no less than eight constants are necessary. The process can be described in one single diagram. It is shown that all thixotropic Bingham and Newtonian bodies must have a non-thixotropic region. A condition for a time-dependent breakdown is a delay in the appearance of thixotropy.

A.

541.182.5 : 539.32

An apparatus for measuring the elastic properties of gels. See Abstr. 4129

541.183

4152. Chemisorption on metals. M. McD. BAKER AND E. K. RIDEAL. Letter in *Nature* [London] **174**, 1185-6 (Dec. 25, 1954).

A new photoelectric method is described for the measurement of the change ΔV in the work-function potential as a function of the surface coverage θ . The curve of ΔV against θ is curved at the commencement and also when $\theta > 0.6$, confirming that the bond strength between adsorbent and adsorbate changes as the electron density in the surface is changed by chemisorption.

S. J. GREGG

541.183

4153. On the effect of molecular interaction in concentrated adsorbed films. L. GUASTALLA AND J. GUASTALLA. *C.R. Acad. Sci. [Paris]* **240**, No. 4, 425-7 (Jan. 24, 1955) In French.

The Duclaux-Traube law is extended to concentrated solutions, when a coefficient is obtained which is greater than the Traube coefficient, for a series of fatty acids and alcohols. The deviation is explained with the aid of the energy of repulsion. The results for lauric acid afford indirect support for the Gibbs adsorption equation.

S. J. GREGG

541.183 : 531.724

4154. The interaction of gas molecules with capillary and crystal lattice surfaces. W. A. STEELE AND G. D. HALSEY, JR. *J. phys. Chem.*, **59**, No. 1, 57-65 (Jan., 1955).

The theory of Abstr. 8740 (1954) has been modified to treat capillary spaces. The effect on the apparent area and energy of interaction is calculated. The interaction of a molecule with the surface of a simple cubic lattice of atoms has been computed and compared with the crude model. Experimental data on the interaction of helium, neon, argon, hydrogen, oxygen, nitrogen and methane with porous glass and saran charcoal are presented and discussed.

A

541.183 : 536.75

4155. Entropy and mobility of adsorbed molecules. VI. Polar gases on charcoal. J. H. DE BOER AND S. KRUYER. *Proc. K. Ned. Akad. Wetensch. B*, **58**, No. 1, 61-72 (1955).

For Pt V, see Abstr. 7835 (1954). Summarizing these conclusions of the previous parts it may be said that (1) methyl, ethyl and *n*-propyl chloride, diethyl ether and ammonia when adsorbed on charcoal in the neighbourhood of room temperature are mobile; (2) the adsorbed molecules of the said chlorides and of diethyl ether rotate freely; the same conclusion may be drawn for ammonia, adsorbed on the charcoals, used by Titoff and by Richardson; (3) at temperatures, lower than room temperature, water is localized when adsorbed on charcoal but at higher temperature mobility sets in; the localized water molecules have lost a considerable part of their rotations; they are, therefore, at least partially, orientated.

A.

541.183 : 539.23 : 537.217

The energy of interaction in an adsorbed film composed of dipoles. See Abstr. 3705

CHEMICAL STRUCTURE 541.2/.6

541.63 : 539.132

4156. On the structure of sym-tetrabromoethane. R. E. KAGARISE. Letter in *J. chem. Phys.*, **23**, No. 1, 207-8 (Jan., 1955).

1, 2 dibromoethane can occur in a trans-form (C_{2h}) or a skew-form (C_s), the former being the more stable. In the solid phase only the trans-form is found. In 1, 1, 2, 2 tetrabromoethane the skew-form has the lowest energy, the difference between trans- and skew-form being 950 cal/mole. The spectrum of this substance in liquid and crystalline phase was investigated in the region 2-15 μ . The bands found are classified, and it is concluded that the crystalline phase consists of trans-forms only. The fact that tetrabromoethane often forms a glassy substance instead of crystals may be due to the difficulty in attaining the trans-form.

A. J. TAYLOR

541.64

4157. The light-scattering and non-Newtonian viscosity of high molecular weight polymethacrylic acid. P. ALEXANDER AND K. A. STACEY. *Trans Faraday Soc.*, **51**, Pt 2, 299-308 (Feb., 1955).

The viscosity of solutions of ionized polymethacrylic acid is non-Newtonian. The behaviour of samples of molecular weight of the order of 2×10^5 is accurately described by the relation of Kuhn and Kuhn (1945) which takes into account the deformation of the molecule due to a gradient of flow. With somewhat greater molecular weights ($> 7 \times 10^5$) the variation of the viscosity with the rate of shear becomes quite different due to strong interaction between molecules. An empirical relationship between molecular weight and viscosity is obtained which takes this effect into account. The molecular weights are obtained from light scattering. The change in the specific refractive index increment on ionization is shown to be important for the molecular weight determinations of the ionized forms. The shape of the particles in dilute solutions of sodium chloride is shown, from the angular scattering functions, to be stiffened random coils highly swollen by the electrostatic repulsion of the ionized groups.

A.

541.67

4158. Magnetochemical investigations. IX. The diamagnetic susceptibilities of acids and esters containing a benzene nucleus. W. R. ANGUS, G. I. W. LLEWELYN AND G. STOTT. *Trans Faraday Soc.*, **50**, Pt 12, 1311-19 (Dec., 1954).

For Pt VIII, see *Trans Faraday Soc.*, **48**, Pt 8, 680 (Aug., 1952). Results of measurements of the diamagnetic susceptibility of 21 acids and esters, using a modified Gouy apparatus, are recorded. Systematic variation in the susceptibilities of the methylene and phenylene groups with the point of their attachment to the carboxyl residue has been observed and the

effect of configurational changes on the molar susceptibilities of isomerides is discussed.

G. I. W. LLEWELYN

541.67

4159. Magnetochemical investigations. X. The diamagnetic susceptibilities of aliphatic ketones and aldehydes. W. R. ANGUS, G. I. W. LLEWELYN AND G. STOTT. *Trans Faraday Soc.*, **51**, Pt 2, 241-5 (Feb., 1955).

The susceptibilities of 22 aliphatic aldehydes and ketones have been measured by the Gouy method. The methylene increments for methyl ketones seem to be slightly lower than those for ethyl ketones; an explanation is advanced. Isomeric effects are considered. Aldehydes are slightly more diamagnetic than isomeric similarly-branched ketones. Restriction of free rotation of alkyl chains lowers susceptibility.

A.

541.67

4160. Magnetochemical investigations. XI. The diamagnetic susceptibilities of aryl aldehydes and ketones and of some dicarbonyl compounds. W. R. ANGUS AND G. I. W. LLEWELYN. *Trans Faraday Soc.*, **51**, Pt 2, 245-8 (Feb., 1955).

Measurements on seven aryl mono-carbonyl and four alkyl dicarbonyl compounds are reported and discussed. The phenylene increments are substantially less than the value previously reported for acids and esters, and a possible explanation is advanced. Effects of isomerism and tautomerism are considered.

A.

CHEMICAL ANALYSIS 543/545

545.827

4161. Precision of mass spectrometer analyses of carbureted water gas. W. VOLK. *Analyt. Chem.*, **26**, No. 11, 1771-4 (Nov., 1954).

Data on mass spectrometer analyses obtained by the National Bureau of Standards in 1950 have been analysed statistically for the components of within-laboratory precisions. About 50% of the within-laboratory variance comes from the spectrometer, the calculators contribute an insignificant amount, operators contribute about 30%, and the balance of the variance is unaccounted for. The within-laboratory mass spectrometer precisions are better than similar precisions by chemical analysis, while between-laboratory checks by mass spectrometer are not as good as similar checks by chemical analysis. The analysis of variance technique used for the precision calculations can be used for other stepwise analytical procedures to find the different components of the variance.

A.

Surface tension in ionic crystals. See Abstr. 3484

548 : 539.375

4165. Investigation of the critical shear stress for single crystals of metallic solid solutions. II. J. O.

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545.827

4162. Determination of carbon-14 in solutions of C^{14} -labeled materials by means of a proportional counter. A. SCHWEBEL, H. S. ISBELL AND J. D. MOYER. *J. Res. Nat. Bur. Stand.*, **53**, No. 4, 221-4 (Oct., 1954).

A study is reported of the determination of carbon-14 in C^{14} -labelled substances by counting, with a proportional gas-flow counter, the radioactive disintegrations arising from a material that is dissolved in a suitable solvent. A number of solvents were found to be satisfactory. Formamide is recommended for the assay of carbohydrates and other materials with which it is a compatible solvent. Ethylene glycol is suitable for the assay of highly alkaline substances, and, in conjunction with sequestering agents, for the assay of alkaline earth carbonates. Other useful solvents are dimethyl formamide and 90% phosphoric acid. The counting efficiency in different solvents was found to be inversely proportional to the density of the solution and highly reproducible. The study shows that solutions of C^{14} -labelled materials can be counted easily and precisely with a proportional counter.

A.

545.827 : 539.172.4

4163. Lithium isotope determination by neutron activation. L. KAPLAN AND K. E. WILZBACH. *Analyt. Chem.*, **26**, No. 11, 1797-8 (Nov., 1954).

The large absorption cross-section of lithium-6 for thermal neutrons, with the resultant production of tritium, is utilized for the isotopic determination of lithium. Solutions of known lithium concentration are irradiated in a nuclear reactor. The tritium produced affords a direct measure of the relative lithium-6 content of the solutions. The only significant interference is from lithium impurity in the quartz irradiation tube. The precision of a lithium-6 determination is within 1%.

A.

545.828

4164. Use of the nitric oxide/oxygen continuum in the estimation of the relative concentrations of oxygen atoms in flame gases. C. G. JAMES AND T. M. SUGDEN. Letter in *Nature [London]* **175**, 252-3 (Feb. 5, 1955).

The intensity of the yellow-green continuum when NO is added to the central part of a H_2 /air flame on a special Meker burner is proportional to the amount of NO added and to the calculated concentration of atomic oxygen, supporting the assignment to the reaction $NO + O = NO_2 + hv$. The emission, and therefore the atomic oxygen concentration, is abnormally high in and just above the inner cones, falling to equilibrium after about 1 cm, equivalent to 1 msec.

A. G. GAYDON

CRYSTALLOGRAPHY 548

548 : 532.612.3

LINDE AND S. EDWARDSON. *Ark. Fys.*, **8**, Paper 51, 511-19 (1954).

In Pt I [Abstr. 7585 (1950)] preliminary results of measurements for pure copper and some dilute copper alloys were given. The results of additional measurements are now reported.

A.

548.1
4166. The geometrical basis of crystal chemistry. III. A. F. WELLS. *Acta cryst.*, 7, Pt 12, 842–8 (Dec., 1954).

Examples are given of some of the 3- and 4-connected three-dimensional nets derived in Pts I and II [Abstr. 11527 (1954)] with special reference to certain groups of hydrogen-bonded structures. The general types of crystal structure are indicated for long molecules such as those of dihydroxy compounds and those containing terminal —CO.NH— groups. The crystal chemistry of P , P_2O_5 , and the trioxides and trisulphides of Group 5B elements is discussed. A.

548.1
4167. The geometrical basis of crystal chemistry. IV. A. F. WELLS. *Acta cryst.*, 7, Pt 12, 849–53 (Dec., 1954).

Structures based on a single net of low co-ordination number are unlikely to occur owing to their low densities. A study has therefore been made of systems of two or more interpenetrating three-dimensional networks. Some of the possible structure types are illustrated. A.

548.1
4168. Crystal chemical studies of the 5f-series of elements. XXIII. On the crystal chemistry of uranyl compounds and of related compounds of transuranic elements. W. H. ZACHARIASEN. *Acta cryst.*, 7, Pt 12, 795–9 (Dec., 1954).

548.2 : 548.735
4169. On the relations between structure and morphology of crystals. I. P. HARTMAN AND W. G. PERDOK. *Acta cryst.*, 8, Pt 1, 49–52 (Jan., 1955).

An attempt is made to find relations between crystal structure and crystal morphology on an energy basis. It is concluded that the morphology of a crystal is governed by chains of strong bonds running through the structure. The effective period of such a chain of strong bonds is called a periodic bond chain vector (P.B.C. vector). The faces of a crystal are divided into three classes: (a) flat faces or *F*-faces, each of which is parallel to at least two P.B.C. vectors; (b) stepped or *S*-faces, each of which is parallel to at least one P.B.C. vector; (c) kinked faces or *K*-faces which are not parallel to any P.B.C. vector. *F*-faces are the most important faces; *S*-faces are of medium importance and *K*-faces are very rare or do not occur at all. Two examples are given, concerning the morphology of diamond and urotropine respectively. A.

548.24
4170. Formulae for the transformation of indices in twinned crystals. K. W. ANDREWS AND W. JOHNSON. *Brit. J. appl. Phys.*, 6, No. 3, 92–6 (March, 1955).

The interpretation of X-ray diffraction patterns from twinned crystals and the solution of other problems involving twin formation can be assisted by the use of certain formulae. Given the indices of the twin plane (*HKL*) or the twin axis [*UVW*], it is possible to find the indices of a plane in the twinned part of a crystal in terms of those of the corresponding plane in the parent crystal, or to formulate the corresponding transformation for zone axes. A general relationship applicable to any crystal systems has been derived in matrix form. A particular form of the

matrix and a new relationship follow for cubic crystals. Examples are given of the use of the matrix and formulae. These refer to twins on {111} planes in face-centred cubic metals and other cubic crystals and to twinning in titanium and in uranium. A.

548.5
4171. Growth of the EDT crystal. Y. KUNIZAKI. *J. Inst. Elect. Commun. Engrs Japan*, 36, No. 12, 672–6 (Dec., 1953) In Japanese.

In the process of growing EDT crystals by the rotary method under cooling, the growth rate for (110) crystals depends on the rotation velocity when this is small and the effect is greater at higher temperature. This indicates that diffusion of the solute through the fluid film on the crystal surface plays an important part in the crystal growth. Since the thickness of the fluid film is not uniform, the rate of growth of the crystal cannot be uniform if diffusion effects are not negligible. The relation between the degree of supersaturation *s* and the growth rate *g* is given by $g = ks^n$, where *k* is a function of the temperature of the solution. Within the ranges of temperature and degree of supersaturation normally used in crystal growing, the value of *n* is from 1.1 to 1.4 for (110) crystals and 2 for (100) crystals. A. WILKINSON

548.5 : 536.421.1
Melting and crystal structure: the melting parameters of some polyphenyls. See Abstr. 3678

548.5 : 539.234
The growth of thin films. See Abstr. 4120

548.52 : 548.74
4172. The study of crystal growth with the electron microscope. IV. The nucleation and growth of *n*-propyl *n*-pentacontanoate. N. G. ANDERSON AND I. M. DAWSON. *Proc. Roy. Soc. A*, 228, 539–48 (March 22, 1955).

The study of long-chain paraffin derivatives in the electron microscope has been extended to include the fatty acid ester *n*-propyl *n*-pentacontanoate, $\text{—C}_{53}\text{H}_{106}\text{O}_2$. Examination of crystals prepared by previously described methods has given information on two further aspects of crystal growth. In the first place micrographs have been obtained at a much earlier stage in the growth of the crystals, before recognizable growth-steps have developed. It would appear that growth arises from sheet nuclei consisting of small condensed monomolecular films of 0.25 to $20\mu^2$ area. Screw dislocations arise at the edge of these sheets through the condensation of molecules in positions of incomplete lattice register. Growth thereafter continues around these dislocation centres, and the resultant spiral is built in towards the centre of the crystal face. This information modifies the Frank (1951) concept of a buckling mechanism for the formation of screw dislocations in crystals, since it places the emphasis on the importance of edge condensation in the formation of lattice disorder and minimizes the importance of strain in the growing perfect lattice. The second finding has been that these crystals frequently occur with a twist boundary parallel to {001}. This effect cannot properly be described as rotational slip of the type discussed by Wilman (1951), since it does not arise through deformation of an already formed crystal but occurs

during growth itself. This twist boundary is penetrated by a screw dislocation or by a group of screw dislocations. A.

548.522

4173. The growth of ice crystals from the vapour. D. SHAW AND B. J. MASON. *Phil. Mag.*, **46**, 249–62 + vi pp. figs. (March, 1955).

The growth and evaporation of single ice crystals have been studied in relation to the temperature and supersaturation of the environment. The sequence of crystal forms which occurs in clouds as the temperature falls from 0°C to –40°C has been reproduced in these experiments. Measurements of the growth rates of individual faces of crystals growing under fixed environmental conditions reveal that $dR^2/dt = \text{const.}$ where R is a linear crystal dimension, but the growth rates of basal and prism faces are different to a degree depending mainly on the temperature. At constant temperature, dR^2/dt varied as the square of the supersaturation σ over the range of σ studied. A critical supersaturation for growth was found which varied in an apparently random manner from face to face, there being no systematic difference between the values for the prism and basal faces. The crystal habit, defined by limiting values of the axis/diameter ratio, was found to be controlled very largely by the temperature, the supersaturation having a much smaller, non-systematic effect. A.

548.535

4174. Floating zone crystallization of silicon. P. H. KECK. *Physica*, **20**, No. 11, 1059–65 (Nov., 1954).

See also Abstr. 6996 (1954). Descriptions of apparatus for producing a molten zone of Si between two solid Si rods in the absence of a containing vessel, to obtain Si single crystals of high purity. Configurations of the molten zone are shown, which are stable for either upward or downward motion of the zone. J. FRANKS

548.55

4175. Growth of lead fluoride crystals from the melt. D. A. JONES. *Proc. Phys. Soc. [London] B*, **68**, Pt 3, 165–70 (March, 1955).

The application of Stockbarger's technique to the growth of PbF_2 crystals is described. The melting point of PbF_2 was found to be $822^\circ\text{C} \pm 2^\circ\text{C}$, and owing to its fairly high vapour pressure at this temperature, the crystals were grown in an atmosphere of oxygen-free nitrogen at a pressure of 2 to 10 mm of mercury. The crystal structure was found to be of the fluorite type, and the lattice constant $5.942 \pm 0.001 \text{ \AA}$ at 18°C . Refractive indices are given for various wavelengths in the visible spectrum. The transmission limits, defined as the wavelength at which a specimen of thickness 1 cm absorbs 50% of the incident radiation, are 11.6μ and $2800 \text{ \AA}$. A.

ATOMIC AND X-RAY CRYSTALLOGRAPHY

548.7

548.7

4176. The geometry of lattice planes. I. M. A. JASWON AND D. B. DOVE. *Acta cryst.*, **8**, Pt 2, 88–91 (Feb., 1955).

A simple but powerful method is outlined for

finding the arrangement of lattice points in a lattice plane of given Miller indices, and for determining the stacking properties of such planes. The theory is extended to cover the case of motif points within the primitive unit cell. A.

548.7

4177. Combinatorial solution of the triangular Ising lattice. R. B. POTTS. *Proc. Phys. Soc. [London] A*, **68**, Pt 3, 145–8 (March, 1955).

The combinatorial method of Kac and Ward [Abstr. 2811 (1953)] is used to derive the partition function of an infinite two-dimensional triangular Ising lattice. The result agrees with that obtained by algebraic methods. A.

548.7 : 539.153

4178. Vibrational modifications of the electron distribution in molecular crystals. II. Mean square amplitudes of thermal motion. P. W. HIGGS. *Acta cryst.*, **8**, Pt 2, 99–104 (Feb., 1955).

For Pt I, see Abstr. 7289 (1953). The calculation of the mean square amplitude of thermal motion of an atom in a molecular crystal is discussed. It is shown that, with certain simplifying assumptions concerning the form of the force field, there should be a linear relation between the mean square amplitude and the square of the distance of the atom from the molecular centre of mass. The relation is found to hold approximately for naphthalene and anthracene, and its validity and limitations are discussed. A.

548.7 : 535.371

Movement of conduction electrons in crystal luminescence. See Abstr. 3629

548.7

4179. Effect of overlap on electrostatic lattice potentials in ionic crystals. J. BIRMAN. *Phys. Rev.*, **97**, No. 4, 897–902 (Feb. 15, 1955).

A calculation has been made of the effect of ionic overlap on electrostatic lattice potentials. The calculation is based on a model which assumes each ion to consist of a core represented by a point charge, and a valence electron density represented by a normalized Gaussian centred at the core site. The contribution of any ion to the potential at a point in the crystal consists of the sum of two terms. One represents the potential due to a neutral configuration (core plus compensating Gaussian); the second the potential due to the unbalanced Gaussian charge of the ion. Upon taking appropriate lattice sums, the lattice potential is obtained in a rapidly convergent form, involving only the usual Ewald sums. The "self-potential" in NaCl and ZnS is evaluated as a function of the half-width α of the assumed Gaussian valence density of the ions. For $\alpha = 0$ the result is the well-known "Madelung Potential." The effect of overlap on the potential at an interstitial site in NaCl and ZnS structures is also examined. From the results of the analysis it can be concluded that lattice potentials are sensitive to ionic overlap, so that the effect of overlap cannot in general be neglected. A table of the available Ewald sums for a cubic lattice is given to aid in the calculation of lattice potentials in cubic crystals. A.

548.7 : 537.311.32

Resistivity and crystal structure. See Abstr. 3721

548.7

4180. A new interpretation of irradiation-induced phenomena in alkali halides. J. H. O. VARLEY. *J. nuclear Energy*, **1**, No. 2, 130–43 (Dec., 1954).

Some experiments on fast electron irradiation of alkali halides are described. It is shown that a displacement collision model based on Rutherford scattering is insufficient to account for the effects noted. A mechanism is suggested whereby atomic displacements may be produced by radiation in ionic solids as a consequence of multiple ionization. The interstitial halogen atoms and metal ions thus formed can migrate under thermal activation and be captured at point vacancies in the crystal lattice. The structural complexes which may result can account satisfactorily for some of the optical absorption bands produced in alkali halide crystals as a result of X-irradiation.

A.

548.7

4181. Thermal ionization of impurities in polar crystals. II. Application to interstitials in cubic ZnS. H. D. VASILEFF. *Phys. Rev.*, **97**, No. 4, 891–6 (Feb. 15, 1955).

For Pt I, see Abstr. 1350 (1955). The general theory of thermal ionization of impurities in a polar crystal is applied to interstitials. The interaction energy of the trapped electron with the optical vibrational modes is included in the electronic wave equation and the normal co-ordinate dependence of the electronic wavefunction and energy is determined through Simpson's method. This leads to an evaluation of the displacements, c , and the configurational constant, S , occurring in the general theory. The numerical evaluation of the frequency factor indicates that it has the form $s(E, T)$ at moderately high temperatures, T , but depends only on the trap depth, E , at low temperatures. The theory is applied to interstitials in the cubic form of zinc sulphide, leading to an activation energy of 0.61 eV, a frequency factor of 10^8 sec^{-1} at low temperatures and of $10^{8.6} \text{ sec}^{-1}$ at 320°K, at which temperature a glow peak is known to occur. These results are in reasonable agreement with experiment.

A.

548.7

4182. On the theory of transitions of F -centre electrons. H. J. G. MEYER. *Physica*, **20**, No. 11, 1016–20 (Nov., 1954).

Assuming a Gaussian form for the F -centre absorption band the variation of half-width with temperature is compared for theory and experiment and for various alkali halides. Small but systematic deviations of experimental from theoretical values are significant and theoretical corrections are developed to explain them.

G. F. J. GARLICK

548.7

4183. K band in additively colored KCl at 18°K. F. E. GEIGER, JR. Letter in *Phys. Rev.*, **97**, No. 2, 560–1 (Jan. 15, 1955).

548.73/.74

X-ray and electron investigation of materials. See also under "Structure of solids." Decimal classification 539.26/.27

548.732

4184. The diffraction of X-rays by a cylindrical lattice. I. E. J. W. WHITTAKER. *Acta cryst.*, **7**, Pt 12, 827–32 (Dec., 1954).

The diffraction of X-rays by a cylindrical lattice is of interest in connection with the structure of chrysotile and some other minerals. A cylindrical lattice model is defined, and it is shown to give a set of reflections in the same directions as certain of the reflections from a rotating crystal. These reflections have a shape similar to that of reflections from a normal crystal, and their integral breadth is evaluated in terms of the number of co-operating cylindrical layers. The amplitudes of the reflections are related to the Fourier coefficients of the electron-density distribution projected on to a radial plane, provided that the projection is defined in a special way. A second set of reflections is also produced which is analogous to, but not identical with, that from a cross-grating.

A.

548.732

4185. Friedel's law in the light of the dynamical theory of interference. H. NIEHRS. *Z. Phys.*, **140**, No. 1, 106–18 (1955) In German.

Considers the validity of Friedel's law. From the standpoint of the dynamical theory of interference this validity is restricted, for non-absorbing crystals, to particular ranges of angles of incidence. These cover simple interference and the case in which two real wave fields appear in the crystal.

J. THEWLIS

548.734

4186. Geiger-counter measurements of single-crystal Bragg reflections. The geometrical problem. F. L. HIRSHFELD AND G. M. J. SCHMIDT. *Bull. Res. Coun. Israel*, **3**, No. 1–2, 37–45 (June–Sept., 1953; publ. Nov., 1953).

Discussion of the movements of the counter and the crystal needed in three possible methods of scanning the reciprocal lattice, and of the use of a plane-convergent X-ray beam to obtain integrated intensities.

J. HAWGOOD

548.734.3

4187. The rapid indexation of lines in X-ray analysis of powder samples by a graphical method. C. NOVÁK. *Czech. J. Phys.*, **4**, No. 4, 496–503 (Nov., 1954).

The principle of the method for powder samples (Debyeograms and electron diffractograms) independent of symmetry, its application and the results attained are described.

A.

548.734.4 : 535.42

4188. The production of fibre diagrams with the optical diffraction spectrometer. A. R. STOKES. *Acta cryst.*, **8**, Pt 1, 27–9 (Jan., 1955).

Two methods are described for producing a fibre diagram of a given structure by superimposing the diffraction patterns of a number of projections of the structure. An expression is obtained for the minimum number of projections required for a faithful representation of the fibre diagram.

A.

548.734.84

4189. Some observations on the probability distribution of X-ray intensities. A. HARGREAVES. *Acta cryst.*, **8**, Pt 1, 12–14 (Jan., 1955).

Wilson's theory for the probability distribution of

X-ray intensities applies only when the unit cell contains a number of atoms of similar scattering power. Consideration is given to the way the distribution is modified when the intensities are dominated by a single atom in the unit of pattern of the structure.

A.

548.735.4

4190. The theory of sign relations between structure factors. W. COCHRAN AND M. M. WOOLFSON. *Acta cryst.*, **8**, Pt 1, 1–12 (Jan., 1955).

All the known sign relationships for the space group $P1$ are reviewed and the value of each for sign determination is critically assessed. The first relationships considered are those which give sign indications directly from intensities. The probability of deriving the sign of U_{2h} from the magnitude of U_h is calculated and it is shown that no other "signs from intensities" relationship is stronger than this one. The probability of the truth of the normal sign relationship $s(h) = s(h')s(h + h')$ is next derived and it is pointed out that the sign of $U_{h'}/U_{h+h'}$ is the probable sign of the h th Fourier coefficient of the squared structure. The slight limitations on sign determination imposed by this fact are defined. Other sections are devoted to the combination of probabilities, to less important sign relationships, and to the determination of signs from intensities for the space group $P2_1/a$. In the light of the results found the claim of Hauptman and Karle to have solved the phase problem is examined. It is concluded that, while their individual probability expressions are correct within certain limits, they have misinterpreted these results.

A.

548.735.4

4191. Some relations between structure factors. R. K. BULLOUGH AND D. W. J. CRUICKSHANK. *Acta cryst.*, **8**, Pt 1, 29–31 (Jan., 1955).

For a centrosymmetric structure of all like atoms, a series of relations between structure factors is derived. The relationship of these results to the Hauptman and Karle statistical formulae for structure-factor sign determination is indicated; but an important difference in the statistical weight of one formula leads to a relation, recently given also by Cochran, for the signs and magnitudes of certain structure factors.

A.

548.735.4

4192. Calculation of geometrical structure factors for space groups of low symmetry. I. E. W. RADOSLOVICH AND H. D. MEGAW. *Acta cryst.*, **8**, Pt 2, 95–98 (Feb., 1955).

Describes a simple calculator for the function $\cos(hx + ky + lz)$. Values of this function can be read directly from tables of $\cos hx$, provided that the origin of the latter can be shifted an amount $(ky + lz)$ at will. A simple mechanical device to do this is described.

A.

548.735.4

4193. A rapid numerical method of calculating structure factors. E. STANLEY. Letter in *Acta cryst.*, **8**, Pt 2, 122–3 (Feb., 1955).

548.735.4

4194. The calculation of structure factors for centrosymmetric monoclinic systems with anisotropic

atomic vibration. J. S. ROLLETT AND D. R. DAVIES. *Acta cryst.*, **8**, Pt 3, 125–8 (March, 1955).

The structure-factor expressions for these space groups, with anisotropic thermal vibration, are derived and listed. They are shown to be similar to those for isotropic vibration save for correction terms which arise because symmetry-related atoms are not oriented parallel to one another. The expressions for general (hkl) structure factors are given first and then simpler forms for two-dimensional analyses are derived. The constants of the ellipsoid of vibration are related to parameters appropriate for least-squares refinement. Finally, extensions to some other symmetries are discussed.

A.

548.735.4

4195. A stencil method for computing structure factors. H. LIPSON AND P. R. PINNOCK. *Acta cryst.*, **8**, Pt 3, 172–4 (March, 1955).

A method of using the Donnay tables for the systematic computation of structure factors is described. The advantages of the method are that it is rapid, that the required apparatus is simple to construct, and that it makes use of existing tables. In addition, a complete record of the contribution of each atom to every structure factor is obtained.

A.

548.735.44

4196. A contribution to the inequality and equality relations in structure analysis. V. SYNEČEK. *Czech. J. Phys.*, **4**, No. 4, 472–7 (Nov., 1954).

On the basis of the non-negativity for electron density in a crystal $\rho(r)$, the existence of inequalities and equalities between the coefficients of the Fourier expansion of the function $\rho(r)\rho(r + t)$ is shown, which limits the choice of phases of the structure factors.

A.

548.735.44

4197. On the use of slope and curvature maps in refinement of crystal structures. E. L. EICHHORN. Letter in *Acta cryst.*, **8**, Pt 1, 63–4 (Jan., 1955).

The maps, which are themselves obtained by Fourier syntheses, give the slope and curvature of the "difference" synthesis, $\rho_{obs} - \rho_{calc}$. They are used in the refinement of atomic parameters.

A. R. STOKES

548.735.44

4198. Fourier transforms and scattering intensities of tubular objects. J. WASER. *Acta cryst.*, **8**, Pt 3, 142–50 (March, 1955).

Fourier transforms and scattering intensities of discrete circles, arcs, cylinders and of tubes consisting of concentric cylinders, are derived and discussed. An expression resembling the structure factor of crystals is given. For all these cases the intensity function shows bands with sharp edges on the inside and long tails in a direction perpendicular to the Z axis (chosen parallel to the axis of the object). The locations in reciprocal space of the edges are determined by the geometry of the nets on which the cylinders are based, while the region close to the Z axis is characteristic mainly of the large-scale structure of the object. Finally, the scattering due to a continuously wound-up sheet, consisting of one or several layers of unit cells, is discussed.

A.

548.735.44 : 518.5

4199. A fast digital computer for Fourier operations. J. M. ROBERTSON. *Acta cryst.*, 7, Pt 12, 817-22 (Dec., 1954).

A digital computer designed for Fourier synthesis is described, which is the mechanical analogue of the usual strip methods. Suitable gear ratios are employed to generate the sine and cosine functions and the outputs are recorded by means of printing revolution counters. The machine is built for high-speed working and two-figure and three-figure coefficients (F -values) can be set in a few seconds. It does not demand any skill or training on the part of the operator. As only complete revolutions of the output shafts are counted, backlash errors are unimportant. The gear ratios are selected to produce a maximum error of less than 5 parts per million with an average error of about 1 per million, so that five-figure accuracy is possible.

A.

548.735.46

4200. Vector maps of structures containing helical chains. E. R. HOWELLS. *Acta cryst.*, 7, Pt 12, 854-7 (Dec., 1954).

A cylindrically symmetrical Patterson is calculated for a simple structure containing straight, parallel helical chains. This is used to calculate composite vector maps representing structures in which the chains run in different directions. These maps show considerable spreading of the vector density. It is concluded that the features exhibited by the Patterson function for horse methaemoglobin, in the regions approximately 5 and 10 Å from the origin, do not conflict with the idea that the structure contains helical chains.

A.

548.735.6

4201. The effects of dislocations on X-ray diffraction. A. J. C. WILSON. *Nuovo Cimento (Ser. 10)* 1, No. 2, 277-83 (Feb., 1955).

No satisfactory general theory of the effect of dislocations on X-ray diffraction exists. The treatment of Wilson [Abstr. 6878 (1952)] provides integral breadths for a powder consisting of long cylindrical particles each with a single axial screw dislocation. The actual expressions are complex, but lead to breadths increasing practically linearly with l , the index of reflection corresponding to the dislocation axis. The results can be generalized to give approximate expressions for similar particles with edge dislocations but expressions for (i) the line profile for a crystal with a single dislocation, and (ii) breadths and profile for crystals with more than one dislocation have not been obtained. The approximate theory of Stokes and Wilson (1944) can be used for this purpose; the accuracy obtained is open to some question. The "tails" of the line profile so found are not particularly pronounced, and the "Cauchy" line profile found experimentally for cold-worked metals by Williamson *et al.* may be a consequence of the general considerations discussed by Eastabrook and Wilson [Abstr. 3114 (1952)], and not of anything particularly characteristic of dislocations.

A.

548.736.1 : 539.26

Relation between the X-ray diffraction diagram and the micrographic appearance of a polygonized crystal of aluminium. See Abstr. 4123

548.736.3

4202. On the crystal structure of tungsten trioxide. G. ANDERSSON. *Acta chem. Scand.*, 7, No. 1, 154-8 (1953).

The crystal structure of WO_3 was investigated. The symmetry has been found to be monoclinic (pseudo-orthorhombic) and belonging to the space-group $C_{2h}^2-P2_1/a$. The positions of the tungsten atoms given by Braekken have been verified with Fourier methods.

A.

548.736.3

4203. The crystal structure of boron oxide. S. V. BERGER. *Acta chem. Scand.*, 7, No. 4, 611-22 (1953).

This has been determined by trial-and-error methods. The unit cell contains three formula units and belongs to the space group $C_3^2-C3_1(C_3^2-C3_2)$. Dimensions and atomic parameters are given. The structure is built up of two sets of BO_4 tetrahedra forming interconnected spiral chains of two types running parallel to the trigonal axis. Within each tetrahedron the strength of one B-O bond equals unity and the strengths of the remaining three bonds equals two-thirds of unity.

A.

548.736.3

4204. Crystal-chemical data on phases of B elements. K. SCHUBERT, E. DÖRRE AND E. GÜNZEL. Letter in *Naturwissenschaften*, 41, No. 19, 448 (1954) In German.

The crystal structure of InS is given, and the lattice constants of In_2Se , In_2Te , $SiAs$, $GeAs$, $GaTe$, $GeAs_2$, In_2Te_3 , $InSe$ and In_2S_3 . The valence-electron configuration of such phases is briefly discussed.

A. R. STOKES

548.736.3

4205. Unit-cell dimensions of lithium fluoride made from Li^6 and Li^7 . J. THEWLIS. *Acta cryst.*, 8, Pt 1, 36-8 (Jan., 1955).

The unit-cell sides of Li^6F and Li^7F are found to be 4.0271 ± 0.0001 Å and 4.0263 ± 0.0001 Å respectively at $25^\circ C$, a fractional difference of about 2×10^{-4} . It is considered that this difference arises from the difference in zero-point energy of these materials. It is to be compared with the calculated value of 3.3×10^{-4} , which is, however, in error by an unspecified amount since it applies only to temperatures above the Debye temperature.

A.

548.736.3

4206. The size of interstitial solute atoms in close-packed metals. K. A. MOON. *J. phys. Chem.*, 59, No. 1, 71-6 (Jan., 1955).

An improved method has been developed for calculating the size of octahedral solute atoms in primary close-packed metallic interstitial solutions from observed X-ray lattice expansion data. Values of the solute-metal bond length have been calculated by this method for the eight solutions for which X-ray data are available. Comparison of these values with bond lengths predicted by the method of Pauling shows that the solute atoms are bound to the lattice by slightly strained covalent bonds. The partial molar volume of the solute is in some cases much larger than would be expected from the degree of misfit alone. It has been shown that such discrepancies can be attributed to the transfer of electrons from the lattice to the solute-metal bonds.

A.

4207. Crystal structure of aluminium nitride. G. A. JEFFREY AND G. S. PARRY. Letter in *J. chem. Phys.*, 23, No. 2, 406 (Feb., 1955).

The structure differs from the ideal wurtzite structure in axial ratio and in the parameter giving the Al-N separation up the trigonal axis. The bond lengths and valence angles are deduced and their values are discussed.

A. R. STOKES

548.736.3 : 535.347

4208. The structure of amethyst quartz and the origin of its pleochroism. C. V. RAMAN AND A. JAYARAMAN. *Proc. Indian Acad. Sci. A*, 40, No. 5, 189-94 + ii pp. figs. (Nov., 1954).

Comparative measurements with clear quartz and amethyst show conclusively that these two materials do not differ measurably in their density. Amethyst and clear quartz also resemble each other in not giving any Tyndall effect of the kind so conspicuously observable with smoky quartz. These facts indicate that amethyst is a crystalline material very similar to colourless quartz in its make-up, but with a different electronic configuration belonging to a lower symmetry class. The optical biaxiality and the pleochroism of amethyst then follow as natural consequences. This view of the nature of amethyst is confirmed by X-ray diffraction studies made with a section plate of amethyst free from internal twinning but exhibiting colour bands and colour sectors over its area.

A.

548.736.4

4209. Crystal chemical studies of the 5f-series of elements. XX. The crystal structure of tri-potassium uranyl fluoride. W. H. ZACHARIASEN. *Acta cryst.*, 7, Pt 12, 783-7 (Dec., 1954).

For Pt XIX, see Abstr. 8094 (1953).

548.736.4

4210. Crystal chemical studies of the 5f-series of elements. XXI. The crystal structure of magnesium orthouranate. W. H. ZACHARIASEN. *Acta cryst.*, 7, Pt 12, 788-91 (Dec., 1954).

548.736.4

4211. Crystal chemical studies of the 5f-series of elements. XXII. The crystal structure of K_3UF_7 . W. H. ZACHARIASEN. *Acta cryst.*, 7, Pt 12, 792-4 (Dec., 1954).

548.737

4212. A test of the usefulness of direct mathematical methods in the structure analysis of a protein. M. F. PERUTZ AND V. SCATTURIN. *Acta cryst.*, 7, Pt 12, 799-800 (Dec., 1954).

A test was made to see how large a fraction of the $h0l$ reflections of horse methaemoglobin obeyed sign relations of the type: $S(h0l) = S(h'0l)S(h + h', 0, l + l')$.

Thirty sign relations were found between the 16 strongest reflections chosen for the test; 22 of these held and 8 failed. A further 56 sign relations were found between any two strong and any one medium reflection; 30 of these held and 26 failed. The results suggest that direct mathematical methods are not likely to give correct results in the structure analysis of proteins, except perhaps in very favourable cases.

A.

548.737

4213. The geometrical basis of crystal chemistry. V. A. F. WELLS. *Acta cryst.*, 8, Pt 1, 32-6 (Jan., 1955). - For Pt IV, see Abstr. 4167 (1955). A preliminary X-ray study of the yellow wool dye Coomassie Yellow 7G is reported. The unusual diffraction effects from dry crystals and the very large unit cell of the wet crystals suggest a framework structure. Although the structures of the crystals are far too complex to analyse directly, some suggestions are made as to the possible nature of the framework.

A.

548.74

4214. Spectrometry of electron diffraction patterns. II. Evaluation of the interference spectrograms and comparison with theory. F. LEONHARD. *Z. Naturforsch.*, 9a, No. 12, 1019-31 (Dec., 1954) In German.

The experimental arrangement described in Pt I [Abstr. 1892 (1955)] has now been used to investigate the chromatic composition of electron beams diffracted from Be, Al and Au. The spectrograms allow values to be obtained for the ratios of the elastically and inelastically scattered components to the incident intensity and their dependence on atomic number and specimen thickness. The energy and angular distribution of the scattered intensity is also obtained. It is found that the total elastic scattering from crystalline materials is smaller than predicted by the scattering formulae of Molière and Debye, the discrepancy increasing with atomic number and thickness. The inelastic component is in general greater than theoretically expected, and the discrepancy increases with atomic number. The atomic form factor for gold calculated from a chromatically filtered diffraction pattern agrees with that obtained from the unfiltered diagram, and both differ from the value given by the Born approximation. For substances of low atomic number the results appear to support the theory of Koppe for inelastic scattering [Abstr. 4134 (1950)], but an appreciable discrepancy exists at high atomic number.

V. E. COSSLETT

548.74

4215. Analysis of diffraction pattern observed by [electron] microscopy. S. YAMAGUCHI. Letter in *Rev. sci. Instrum.*, 26, No. 1, 89-90 (Jan., 1955).

GEOPHYSICS 55

550.38

4216. Geomagnetic and geoelectric variations. J. G. SCHOLTE AND J. VELDKAMP. *J. atmos. terrest. Phys.*, 6, No. 1, 33-45 (Jan., 1955).

The geomagnetic variations and their relation to earth-currents have been investigated, especially the

pulsations with periods of 10 to 10^2 sec. A world-wide survey of a few examples of pulsations indicates that the source of the phenomenon may be the ionospheric vibrations caused by a disturbance of the ionization equilibrium. The connection with the electric field induced in the earth was studied by

measuring the ratio of amplitudes of the N-S component H_y of the magnetic field and the E-W component E_x of the electric field; the phase-difference between these quantities has been determined for a great number of pulsations. As it was doubted if the theory of plane waves reflected by a plane earth was valid in this case, the earth's radius being small compared with the wavelength of these vibrations, the reflection by a sphere has been investigated theoretically. The results are very similar to those of the plane-earth theory, with the exception of the ratio between horizontal and vertical magnetic components. The values of E/H and of the phase-difference between electric and magnetic variations depend on the structure of the earth; it is therefore possible to derive some knowledge of the upper layers from the measurements. In this way some information with respect to the distribution of the conductivity in the ground at the observatory Witteveen has been obtained. A.

550.93

4217. Age of the earth. C. PATTERSON, G. TILTON AND M. INGRAM. *Science*, **121**, 69–75 (Jan. 21, 1955).

A critical analysis of the method of determining the age by comparison of the Pb^{207}/Pb^{206} ratio for recent lead from the earth where appreciable quantities of uranium are present and for iron meteorite lead from which uranium is absent. It is concluded that the approximate value of 4.5×10^9 yr obtained by this method should be viewed with considerable scepticism until the basic assumptions are verified. J. M. HOUGH

550.93 : 539.16.08

4218. Radiocarbon dating system. G. J. FERGUSSON. *Nucleonics*, **13**, No. 1, 18–23 (Jan., 1955).

The sample carbon is converted to CO_2 which is purified and used to fill a 7.7 litre proportional counter to 3 atm pressure. A very low background is achieved by thick γ -ray shielding and a ring of anti-coincidence G.M. counters surrounding the large proportional counter (to reduce meson counts). A 2-day count gives sufficient accuracy to extend dating range to 45 000 years. L. R. SHEPHERD

551.16

4219. The densities of compounds at high pressures and the state of the earth's interior. L. KNOPOFF AND R. J. UFFEN. *J. geophys. Res.*, **59**, No. 4, 471–84 (Dec., 1954).

A quantum statistical method, already well developed for pure elements, has been extended to the prediction of the equation of state of compounds at extremely high pressures at absolute zero. Application of a finite-strain condition to possible constituents of the earth, found by Birch to be valid for many materials, leads to satisfactory interpolation between the existing laboratory data and the quantum predictions for these materials. The quantum calculations begin to hold at pressures of the order of 10^{14} dyne/cm², pressures greatly exceeding those obtainable within the earth. The finite-strain interpolative procedure is assumed to predict the pressure-density relationships at pressures corresponding to those prevailing within the earth. From Bullen's pressure-density values for the earth, it is found that, assuming the absence of phase transitions, the base

of the mantle has the same density as an olivine possessing 63% Mg_2SiO_4 . By a similar procedure, the earth's outer core cannot be pure iron, but has the same density as a mixture of 90% iron and 10% olivine. For the temperatures prevailing within the earth, the quantum calculations at absolute zero are not significantly altered; a latitude in the interpolative procedure is indicated at these temperatures, leading to a composition of olivine at the base of the mantle ranging between 47 and 63% Mg_2SiO_4 . A.

ATMOSPHERE . METEOROLOGY 551.5

551.508.25 : 551.576

4220. Receiver for measuring the temperature of clouds. A. BAYLE. *Rev. Opt.*, **33**, No. 10, 507–13 (Oct., 1954) In French.

Clouds radiate in the region 8–12 μ , where the atmosphere is transparent. This band is effectively isolated by transmission through a fluorite window followed by either (a) absorption (for $\lambda > 8 \mu$) in a mica window that forms one wall of a gas thermometer, or (b) transmission through a window of AgCl coated with Ag_2S and absorption in a back-silvered glass slip in contact with a thermopile. A cloud is focused on the device with a mirror and temperatures are measured to $\pm \frac{1}{2}$ deg C for (a) or ± 2 deg C for (b). G. F. LOTHIAN

551.508.8 : 551.594.11

4221. Measurement of the electrical potential gradient in the atmosphere by radiosonde. S. P. VENKATESHWARAN, B. K. GUPTA AND B. B. HUDDAR. *Indian J. Meteorol. Geophys.*, **5**, No. 3, 253–6 (July, 1954).

Difficulties existed with the earlier model due to variations of load resistance with temperature, and of characteristics from valve to valve as well as a restricted range of audio frequency. In the later model the audio frequency range is doubled and the total weight reduced by using the internal resistance of the HL23 valve between grid and cathode. When the atmospheric potential between the cathode and the plate of the valve varies, the internal resistance of this valve will also vary and cause a corresponding variation in the audio frequency of the radiosonde. The record of one flight into the stratosphere is shown and details are given of the changes of potential gradient at various heights when passing through Cu, Ac, Cb and Cc clouds. Methods of making polonium collectors are given. R. S. READ

551.510.535

4222. The effect of the solar tides and the temperature change on the daily variation in electron density and height of the F2-layer. T. SHIMAZAKI. *J. Geomagn. Geoelect.*, **6**, No. 2, 68–82 (June, 1954).

Chapman's ion-production function in an isothermal ionosphere is first reformed for the convenience of applying it to the ionosphere with the temporal variation of temperature. Then using this ionization function, the equation of motion and the equation of continuity are solved, taking both the thermal- and

tidal-variations into account. As a result, the maximum electron density and its corresponding height can be obtained for each hour during a day. Departures of these from the normal of the static Chapman region indicate that the behaviour of this departure Δn_m is very different from that described by Weiss, who deals only with tidal effect on the ionosphere. In the present case it is inversely proportional to the temperature variation in the course of a day except in the morning when the electron density is very small. It is also noted that the semi-diurnal variation in Δn_m appears even if the case of only the diurnal variation in temperature is taken into account, and not the tidal variation. As regards the behaviour of Δh_m , a result similar to Weiss's was observed. Further, the simultaneous effect of temperature and tidal variation in the daily variations in the maximum electron density and height seems to show complicated mutual interaction between these two effects. A.

551.510.535

4223. Electron densities in the ionosphere. J. C. SEDDON. *J. geophys. Res.*, **59**, No. 4, 463-6 (Dec., 1954).

A curve of electron densities obtained from rocket experiments [Abstr. 11612 (1954)] showed a sharp decrease in electron density at 145 km. Another interpretation of the data eliminates this decrease. The new interpretation is based on a breakdown in independence of propagation of the magneto-ionic components of a CW-signal transmitted from the flying rocket. The down-going extraordinary ray was transformed into an ordinary ray at an electron density corresponding to approximately the critical frequency for the ordinary ray. The newly-deduced electron-density curve is in excellent agreement with the P' - f records taken simultaneously. The $F1$ -“layer” is merely a low-gradient shelf between 140 and 149 km. A small portion of the steep gradient of the $F2$ -layer is observable at 150 km. A composite graph of all rocket results above 90 km is shown. The only common feature observable in the rocket data when sporadic- E appeared on the P' - f records was a steep electron-density gradient near the peak electron density of the E -layer. A.

551.510.535

4224. Continuous electron density measurements up to 200 km. J. C. SEDDON, A. D. PICKAR AND J. E. JACKSON. *J. geophys. Res.*, **59**, No. 4, 513-24 (Dec., 1954).

Measurements in the ionosphere using the Seddon propagation technique were conducted with the Viking 10 rocket, launched on May 7, 1954, at the White Sands Proving Ground, New Mexico. This rocket reached a record altitude of 219 km, and provided very good data for both upward and downward trajectories. Ordinary and extraordinary indices of refraction at 7.754 Mc/s were measured in the region surrounding the rocket. From these indices it was possible to determine accurately the electron distribution from 84 to 200 km. By using the P' - f records taken during the rocket flight, the electron density curve was extrapolated up to the maximum of the $F2$ -region (2.9×10^5 el/cm³ at 288 km). The measurements showed a rapid increase in density from 1×10^4 el/cm³ at 91 km to 1×10^5 el/cm³

at 101 km. This was followed by additional but less rapid increases up to the peak of the $F1$ -region (2.1×10^5 el/cm³ at 170 km). Densities in the 170 to 200 km region were, in general, five to ten % lower than the $F1$ maximum density. Although obtained during a period of low sunspot activity, these latest results agree remarkably well with previous results reported by Seddon and Jackson for periods near the sunspot maximum. In all cases, the daytime ionosphere was seen to remain dense throughout the E -region and up to the $F1$ -region, with only occasional minor peaks in density. In all cases, the distribution obtained agreed very closely with the P' - f records. Sporadic echoes are apparently due to partial reflections from high-gradient regions. A.

551.510.535

4225. The development of an E -region model consistent with long wave phase path measurements. R. E. JONES. *J. atmos. terrest. Phys.*, **6**, No. 1, 1-17 (Jan., 1955).

The diurnal and seasonal variations in phase height of the main E -region reflection level at 150 kc/s are summarized for a period of 15 months. An electron density model, moderately “sharp” on the lower side, is evolved by modification of the Chapman theory to include the effects of variable scale height, dissociation of molecular oxygen and variable recombination. The model is checked, primarily, against 150 kc/s phase height data, but also against 2.4 Mc/s phase heights and E -region critical frequency. A.

551.510.535

4226. Ionospheric absorption measurements at Prince Rupert. K. DAVIES AND E. L. HAGG. *J. atmos. terrest. Phys.*, **6**, No. 1, 18-32 (Jan., 1955).

Measurements of the ionospheric absorption of high-frequency radio waves made at Prince Rupert, British Columbia, are described. The dependence of the total local noon absorption, $-\log \rho$ on wave frequency, does not appear to obey the inverse square law, i.e. $-\log \rho \propto 1/(f + f_c)^2$. Studies of the seasonal variation of noon absorption show little dependence on solar zenith angle χ but indicate that abnormally high absorption is present during the winter months. The diurnal variation can be represented very approximately by the expression $-\log \rho \propto (\cos \chi)^n$ where n is about 0.5 on the average. There is a pronounced correlation between night-time ionospheric absorption on 2.0 Mc/s and the three hour range magnetic K index for values of K greater than 4. It is also found that high night-time absorption is often associated with occurrence of intense sporadic- E . A.

551.510.535

4227. The autocorrelogram of randomly fading waves. R. B. BANERJI. *J. atmos. terrest. Phys.*, **6**, No. 1, 50-6 (Jan., 1955).

The power spectrum returned by a completely rough ionosphere having a random motion superposed on a steady drift is deduced. The autocorrelograms of fading patterns corresponding to power spectra returned by the two extreme cases of this spectrum, i.e. pure drift and pure turbulence, are compared and the possibility of statistically distinguishing between

them discussed. On the basis of a test of significance of autocorrelograms it is shown that a fading pattern need not contain more than 250 independent points to make a distinction between two possible types of autocorrelograms. The effect of antenna polar diagrams on the autocorrelograms is also discussed qualitatively. A.

551.510.535

4228. Ionospheric nomenclature and conventions for analysis [of records]. K. BIBL, R. BUSCH, K. RAWER AND K. SUCHY. *J. atmos. terrest. Phys.*, **6**, No. 2-3, 69-87 (March, 1955) In French.

A proposal is made for the classification of the ionospheric layers according to their thickness. Transitory phenomena are not to be classified amongst the normal layers; the corresponding layers are always thin. The fundamental notions in use with ionospheric records are defined more exactly, the rôle of the ionosonde is also defined. In order to define the term "critical frequency" in such a way that it can also be applied to thin layers, account is taken of the intensity of the different echoes. The phenomenon of "partial reflection" cannot be neglected. It is necessary to distinguish between characteristics which are directly readable and those which are found by extrapolation. Proposals are also made for more generally applicable definitions of the "descriptive letters." A.

551.510.535

4229. Ionospheric behaviour at Khartoum during the eclipse of 25th February 1952. C. M. MINNIS. *J. atmos. terrest. Phys.*, **6**, No. 2-3, 91-112 (March, 1955).

Automatic $h'f$ records were made at intervals of four-and-a-quarter minutes during the eclipse and at quarter-hour intervals on ten control days. The behaviour of both E - and F_1 -layers can be explained in terms of Chapman layers having constant effective recombination coefficients ($\alpha'E = 1.5 \times 10^{-8} \text{ cm}^3 \text{ s}^{-1}$, $\alpha'F_1 = 8 \times 10^{-9} \text{ cm}^3 \text{ s}^{-1}$), and assuming a non-uniform distribution of the sources of ionizing radiation on the sun's disk. It has been possible to derive the positions and relative intensities of these sources from the E -layer data, and they appear to be related to the location of sources of intense green coronal radiation. The F_2 -layer response to the eclipse is consistent with the assumption of two component layers: a lower one, corresponding to the normal post-sunrise F_2 -layer, which is sensitive to changes in solar radiation and has a high α' , and an upper one which is a later development of the lower layer but which is insensitive to solar radiation and has a small α' . Changes in the absorption in D -layer confirm the asymmetrical distribution of sources of ionizing radiation. Although fEs showed a very deep minimum about an hour after totality, there is nothing to suggest that this was an eclipse effect, nor is there any evidence for a corpuscular eclipse in F_2 -layer about two hours before the optical eclipse. A.

551.510.535

4230. Studies on the sunrise effect in regions E and F . S. S. BARAL. *J. atmos. terrest. Phys.*, **6**, No. 2-3, 160-70 (March, 1955).

The characteristics of an ionospheric layer are

known to undergo variations during sunrise in the layer (sunrise-effect). The sunrise-effect begins not when the solar rays first strike the layer, but later. This delay phenomenon in the "sunrise-effect" has been studied for the E - and F -regions of the ionosphere at Calcutta during the period January, 1947, to June, 1952. It is shown that the observed delay times can be explained as due to the difference between the night-time and daytime heights of an ionospheric layer. The early-morning rays which strike the night-side of the ionospheric layer and increase its ionization, must pass above the daytime height of the layer, in order that the active wavelengths do not get absorbed by the thickness of the air through which the rays pass. The measured daytime height of the layer (after the occurrence of the sunrise-effect) agrees reasonably well with the height grazed by the solar rays which strike the night-time height of the layer at the time of commencement of the sunrise-effect. A.

551.510.535

Radio-wave propagation in the ionosphere. See also under "Electromagnetic waves and oscillations." Decimal classification 538.566.3

551.510.535 : 550.385

4231. On the world-wide disturbance in F_2 -region. T. OBAYASHI. *J. Geomagn. Geoelect.*, **6**, No. 2, 57-67 (June, 1954).

The world-wide patterns of the F_2 -region disturbance and their development in relation to geomagnetic storm-time were examined with the comprehensive world-wide data of the F_2 -layer. The average disturbance in f_oF_2 during the main phase of the associated magnetic storm, so-called $D(f_oF_2)$, was derived with respect to geomagnetic latitude and local time, and it was separated into the $Dst(f_oF_2)$ and $Ds(f_oF_2)$ component. It is shown that these two components play an important rôle in ionospheric storms, and that not only their range, but also their phase is controlled by the magnetic activity. The average development course of the ionospheric storm and the mode of the $Ds(f_oF_2)$ changing regularly with storm-time, were studied. The phase of the $Ds(f_oF_2)$ during the active stage of a magnetic storm is almost uniquely dependent upon local time, but after the activation ceases, the pattern of the disturbance moves together with the rotating earth. Detailed analysis was made on the progressive aspects of the individual disturbances in the northern hemisphere accompanied by some typical severe magnetic storms. A.

551.510.535

4232. On the interpretation of the measurements of the ionospheric F_1 layer. K. RAWER. *C.R. Acad. Sci. [Paris]* **240**, No. 3, 331-3 (Jan. 17, 1955) In French.

The critical frequency f_oF_1 requires a more precise definition, as its measurement from ionograms is often ambiguous due to there being no sharp discontinuity between the F_1 and F_2 layers. Considering the production of ionization in the two regions, with a "transition zone" between, the measured values of f_oF_1 must be corrected before they can be interpreted in terms of electron densities. G. M. BROWN

- 551.513
4233. Atmospheric turbulence and diffusion. I. K. R. SAHA. *Indian J. Meteorol. Geophys.*, **5**, No. 3, 205–18 (July, 1954).

A summary is given of much of the recent work by many authors in several fields. These include (1) the turbulent boundary layer and its hydrodynamical treatment, (2) eddies as diffusing agents (a) transfer of heat in the vertical by eddies, (b) eddy transfer of momentum or vorticity, the mixing length hypothesis, and variation of wind with height, (c) turbulence in a gravitating field, and Richardson's criterion, (d) diffusion of matter in a turbulent medium, and (3) the statistical theory of turbulence and the treatment of diffusion.

R. S. READ

551.59 : 539.172.4

- 4234. Effects of atomic explosions on weather.** L. MACHTA AND D. L. HARRIS. *Science*, **121**, 75–81 (Jan. 21, 1955).

A study of the possible effects of the Nevada atomic tests shows that no departures from normal in precipitation and temperature are recorded in the U.S.A. as a result. The increase in tornadoes during 1953 is probably due to improved record keeping. Various mechanisms for weather effects were studied, but none seemed to be theoretically capable of producing effects at distances of more than a few miles from the explosion.

J. M. HOUGH

551.593.5

- 4235. Atmospheric scattering and absorption of ultra-violet sunlight.** G. F. WALTON. *Phil. Mag.*, **46**, 281–92 (March, 1955).

The scattering of a parallel beam of unpolarized sunlight in a plane-stratified atmosphere is considered, taking into account the polarization of scattered light and allowing for the optical anisotropy of the molecules of air. Allowance is also made for the attenuation of the ultraviolet light due to absorption by atmospheric ozone. Expressions are derived for the intensities of the primary, secondary and tertiary scattered light emitted and received in any direction and at any point in the atmosphere.

A.

551.593.9

- 4236. On the occurrence of the sodium D lines in night sky light and in the aurora.** G. CARIO AND U. STILLE. *Abhandl. Braunsch. Wiss. Gesell.*, **6**, 62–6 (1954) In German.

In the course of investigations of the twilight-effect of the D-lines of sodium 14 spectra were photographed on March 1, 1941, showing the strong aurora on this evening. The spectra prove unambiguously that the twilight-effect occurs completely undisturbed and independent of the aurora observed at the same time; i.e. the layers normally emitting the D-lines in the night sky are not affected by the aurora. The auroral spectrum does not contain the D-lines. Thus the aurora took place above the layer emitting the D-lines in the night sky. Occasional observations of the D-lines in aurorae of higher layers indicate that in such cases the sodium was of extraterrestrial origin.

A.

551.593.9

- 4237. The altitudes of the luminous layers in the earth's atmosphere.** E. V. ASHBURN. Note in *J. atmos. terrest. Phys.*, **6**, No. 1, 67 (Jan., 1955).

It is pointed out that, when the influence of the

atmospheric extinction on the observed ratio of air-glow intensity at zenith distance, z , to that at the zenith, is taken into account, the experimentally deduced heights of the various emitting layers in the terrestrial atmosphere are found to agree well with those predicted on theoretical grounds [Abstr. 9843 (1954)].

D. R. BARBER

551.593.9

- 4238. Measurement of the Doppler width of the $\lambda 577$ line in the night sky.** D. Q. WARK AND J. M. STONE. Letter in *Nature [London]* **175**, 254–5 (Feb. 5, 1955).

From a recent photographic study of the Fabry-Perot fringes of the 5777 Å Or line in the night sky, using a 45 mm dielectric-film interferometer and an F2.5 objective, f.l. 7 cm, a probable Doppler width at $\frac{1}{2}$ max. intensity of 0.0135 Å is deduced, corresponding to a probable atmospheric temperature of $\sim 193^\circ\text{K}$. This value would be expected at 100 km, viz. about $\frac{2}{3}$ of the usually accepted height of the 5777 Å emission.

D. R. BARBER

551.593.9

- 4239. New wavelength measurements of the red radiations, $^1D_2 \rightarrow ^3P_2$, and $^1D_2 \rightarrow ^3P_1$ of the neutral atom of O in the night-sky light.** J. CABANNES AND J. DUFAY. *C.R. Acad. Sci. [Paris]* **240**, No. 6, 573–6 (Feb. 7, 1955) In French.

Interferometric measures of the two Or lines, using an air-spaced étalon and Fl.95 objective, give the following mean wavelengths, 6300.301 ± 0.004 Å, and 6363.790 ± 0.004 Å.

D. R. BARBER

551.594.14

- 4240. On atmospheric radioactivity of atomic origin.** H. GARRIGUE. *C.R. Acad. Sci. [Paris]* **240**, No. 2, 178–80 (Jan. 10, 1955) In French.

See Abstr. 7215 (1949). An improved collector has been installed in the aerial laboratory, but in recent months little activity caused by atomic explosions has been detected.

J. M. HOUGH

551.594.21

- 4241. Observations on the negatively-charged column in thunderclouds.** C. A. HACKING. *J. geophys. Res.*, **59**, No. 4, 449–53 (Dec., 1954).

Simultaneous observations at three stations of the field-changes due to lightning discharges to ground have been used to obtain information on the negatively-charged column of Malan and Schonland [Abstr. 9856 (1951)]. It is found that successive strokes come from regions of increasing height, but that there are occasional considerable horizontal displacements as well. The axis of the column is frequently displaced by several kilometres from the point of emergence of the flash from the cloud.

A.

551.594.22

- 4242. Point discharge currents from a captive balloon.** J. A. CHALMERS AND W. W. MAPLESON. *J. atmos. terrest. Phys.*, **6**, No. 2–3, 149–59 (March, 1955).

Measurements are described of the point discharge current, I , from a point attached to a captive balloon, and these have been correlated with the height, h , the potential gradient at the ground, F , and the wind-speed, W . An approximate theoretical formula is

developed, giving $I = K(Fh)^{q-1}W^{3-q}$. The observational results check the validity of certain aspects of this formula within a limited range of the parameters, with q about 2.77 and K about 0.02 (or 0.015 after estimating a correction for systematic error in F) when I is measured in μA , Fh in kV and W in km/hr. Measurements for an eight-point discharger show that this gives in all about half the current from a single point under similar conditions. A.

551.594.5

4243. Intensity measurements of the second positive band system of nitrogen in high-latitude aurorae. A. OMHOLT. Note in *J. atmos. terrest. Phys.*, 6, No. 1, 61-3 (Jan., 1955).

New intensity distributions of the near-ultraviolet bands of the second positive system of nitrogen (N_2 , $C^3\Pi_u \rightarrow B^3\Pi_g$) have been obtained from 2-prism spectrograms of high-latitude aurorae. Plate calibration was effected by an additional exposure to a nitrogen discharge lamp through a step-filter at the spectrograph slit. Intensities in three bands of the first negative system, and in eight bands of the second positive system of N_2 are listed. D. R. BARBER

551.594.51 : 535.33

4244. Measurements of the specific intensities of the auroral green line at College, Alaska. E. V. ASHBURN. *J. atmos. terrest. Phys.*, 6, No. 1, 57-60 (Jan., 1955).

The specific intensities of the brightest part of the aurorae were found to range up to at least 3.8×10^{-5} ergs/cm².sec.deg². for the 5577 Å line. This is approximately seventy-five times the intensity of the zenith night sky with no moonlight. The frequency distribution of the intensities of the brighter aurorae are given. Data are also presented which indicate that the intensity of the aurorae increases with increasing zenith distance toward the magnetic north. A.

551.594.51 : 535.333

4245. Vibrational temperatures from second positive bands. D. M. HUNTER AND G. G. SHEPHERD. Note in *J. atmos. terrest. Phys.*, 6, No. 1, 64-6 (Jan., 1955).

The measurement of relative intensities and the derivation from them of vibrational temperature in the second positive band system of N_2 are discussed. It is concluded that measurements may be confined to the $\Delta v = 2$ sequence in the near ultraviolet. A rather large number of measurements made with a photoelectric spectrometer are shown to lead to a vibrational temperature between zero and 1000°K; it is inherently impossible to distinguish any temperature in this range. The vibrational temperature therefore does not disagree with the kinetic temperature. Measurements by some other workers are briefly discussed. A.

BIOLOGY 57/59

577.15.037 : 591.185

4246. Test of the magnetic theory of homing. A. R. ORGEL AND J. C. SMITH. *Science*, 120, 891-2 (Nov. 26, 1954).

A laboratory test of the effect of magnetic lines of force moving through two female (*Columbia livia*) stationary pigeons. Electric shock was used as the unconditioned stimulus, and Vincent curves of the acquisition of conditioned responses for buzz, light and magnetic shocks are given. For the magnetic-field/shock sequence the bird cage was surrounded by a vertical solenoid and fields of 0-5 gauss, varying 120 times per sec were used. No apparent learning occurred during the magnetic sequence. S. WEINTROUB

578.088.5 : 535.343

Biological applications of infrared spectroscopy. See Abstr. 3589

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.843

4247. Functional structure of the retinal fovea and Maxwell's spot. K. ISOBE AND K. MOTOKAWA. Letter in *Nature [London]* 175, 306-7 (Feb. 12, 1955).

The method of electric phosphenes [Motokawa, *Journal of Neurophysiology*, 12, 291 (1949)] has been used to show that the entoptic Maxwell spot is due not to selective light absorption by the macular pig-

ment, but to regional variations of retinal receptor functions. 1 fig., 5 refs. R. A. WEALE

612.843.2

4248. The influence of the retinal illumination gradient and its variations on the subjective sensation of brightness. A. FIORENTINI. *Atti. Fond. Ronchi*, 10, No. 1, 54-60 (Jan.-Feb., 1955).

The visual effect which is apparent when a uniform field is viewed through a hole placed close to the eye, is visible also when the subject looks at the shadow of an object illuminated by an extended source: a bright line is seen close to the boundary between the illuminated field and the penumbra. It has been demonstrated that this effect is due only to the eye and it has been referred to the phenomenon discovered by Mach and studied by a number of researchers. This effect is due to a rapid change of the illumination gradient on the retina. Two experiments have been carried out to investigate the dependence of visibility of the bright line upon field luminance and observation time. A.

612.843.367 : 535.241.44

Effect of a peripheral glare source upon the apparent brightness of an object. See Abstr. 3539

612.843.37

4249. The bleaching and regeneration of rhodopsin in the living eye of the albino rabbit and of man. W. A. H. RUSHTON, E. W. CAMPBELL, W. A. HAGINS AND G. S. BRINDLEY. *Optica Acta*, 1, No. 4, 183-90 (Feb., 1955).

612.843.37
4250. On the increase of the amount of night myopia at levels lower than 10^{-3} cd/m². A. IVANOFF AND C. BOURDY. Letter in *Optica Acta*, 1, No. 4, 192 (Feb., 1955) In French.

There is a close correlation between measurements of maximum night convergence and the change in night myopia occurring between the levels I_1 and I_2 of 10^{-3} and 5×10^{-5} cd/m². It is concluded that night myopia at levels higher than I_1 is due to spherical aberration and the Purkinje effect, but at those between I_1 and I_2 to convergence. 1 table, 2 refs. R. A. WEALE

612.843.51 : 535.65
4251. Complementary hues of after-images. M. H. WILSON AND R. W. BROCKLEBANK. *J. Opt. Soc. Amer.*, 45, No. 4, 293-9 (April, 1955).

By a simple adaptation of disk colorimetry the hues of negative after-images of coloured surfaces are ascertained to within the equivalent of 1.0 step of Munsell hue. There is good agreement among a number of observers. The complementary pairs thus obtained show differences from those established additively, particularly in the orange-blue region. The relationship between the two sets of complementaries appears to be connected with the change of hue which occurs when colours are desaturated by additive mixture. This change of hue also accounts for the non-uniform spacing of hues which is a necessary feature of colour circles based on additive complementary pairs. From the observed changes of hue over a range of colours, lines of constant hue are plotted. A.

612.843.613
4252. Comment on Aguilar and Stiles' discussions of their increment threshold measurements. M. A. BOUMAN. Letter in *Optica Acta*, 1, No. 3, 155-6 (Dec., 1954).

Theoretical reasons based on the two-quanta hypothesis explain why the results of Aguilar and Stiles [Abstr. 1929 (1954)] cannot be used to test Rose's fluctuation theory [Abstr. 1971 (1948)]. R. A. WEALE

612.843.72
4253. Experiment demonstrating instability of retinal directional values. K. T. BROWN. *J. Opt. Soc. Amer.*, 45, No. 4, 301-7 (April, 1955).

An experiment is described in which measurements were made of the difference between apparent size on the right and left sides of the fixation point. This measurement is called a half-meridional difference (HMD). A point of light was fixated, and two side points were adjusted by the subject to give apparent equality between the left and right distances. Monocular determinations of the HMD were made with the left and right eyes of three subjects over periods of from four to six weeks. Changes in the HMD as a function of time occurred in all three subjects. In two subjects the changes were quite marked and progressive. This means that changes occurred in the relation between apparent size on the right and left sides of the fixation point. These changes were too large and too well co-ordinated in the left and right eyes to be attributed to changes in ocular dioptric factors. Thus they must be attributed to changes in the subjective directional values which result from stimula-

tion of particular retinal points (retinal local signs). These changes in retinal directional values have therefore been demonstrated with maximally simple test stimuli, which cannot be considered illusory, and in the absence of any type of distorting optical device. It has also been shown that when the changes in HMD are measured for a time in only one eye, subsequent measurements show that concomitant changes were occurring in the other eye. This makes it very likely that the physiological process, which is responsible for the changes in retinal directional values, is located at least as far back in the visual system as the primary visual cortex. A.

612.843.721
4254. On foveal and peripheral interaction in binocular vision. M. A. BOUMAN. *Optica Acta*, 1, No. 4, 177-83 (Feb., 1955).

Contrast and incremental thresholds were measured by the presentation of the test stimulus in one of the eyes, adapting fields of mutually different brightnesses and colours being incident in both eyes. No essential influence was found on threshold value under such stimulation of the non-measuring eye, the threshold being equal to the value appertaining to exclusive stimulation of the measuring eye. Periods of dominance of the various stimuli can under certain conditions easily be recognized. Measurements of increment thresholds under fluctuating illumination of the opposite eye at various moments during the light-dark cycle of such stimulation show a complex behaviour apparently due to a non-peripheral mechanism. Some suggestions are made as to a possible influence of attentional effects on such measurements. A.

612.843.721
4255. Relative contribution of disparity and convergence to stereoscopic vision. A. A. RADY. Letter in *Nature (London)* 175, 305-6 (Feb. 12, 1955).

Wright's apparatus [Abstr. 5950 (1951)] was used in a new determination of the relation between stereoscopic acuity and retinal position. The contributions of convergence and disparity are separated: the former is found to be independent of the angle θ subtended at the eye between the two test-targets, the latter decreases as θ is increased. 1 fig., 3 refs.

R. A. WEALE
 612.845
4256. Congenital achromatopsia. R. A. WEALE. Letter in *J. Opt. Soc. Amer.*, 45, No. 1, 64-5 (Jan., 1955).

The term "congenital achromatopsia," as applied to rod monochromats is unspecific because also cone monochromatism can be congenital. There is no evidence that the light sensations observed in either case are achromatic from the "normal" point of view.

R. A. WEALE
 612.846
4257. Eye-movements in relation to retinal action. R. W. DITCHBURN. *Optica Acta*, 1, No. 4, 171-6 (Feb., 1955).

Experiments are described in which the subject wears a contact lens to which small flat mirrors are attached. Beams of light reflected from these mirrors are received on a recording drum and may be used to

record the rotations of the eye about three mutually perpendicular axes. When the subject is fixating a target as closely as possible, involuntary movements of the eyeball scan the visual axis through angles which are large compared with the visual angle corresponding to the diameter of a retinal receptor. By using the beam reflected from the contact lens it is possible to present the subject with an object which moves so that its image on the retina remains stationary. It is found that the contrast sensitivity and visual acuity in respect of this image are much less than in normal vision. Results are discussed in connection with the recordings of nerve impulses made by Hartline. It is suggested that appreciation of a pattern is controlled by a strong response of the receptors when the eye is scanned across the pattern by the normal involuntary movements. A.

612.858

4258. Variations in sound pressure produced in guinea-pig ears due to normal and abnormal eardrums. R. W. BENSON AND D. H. ELDREDGE. *J. Acoust. Soc. Amer.*, **27**, No. 2, 373-5 (March, 1955).

Sound pressures measured with a probe-tube microphone in front of the tympanic membrane of the guinea pig have been compared at 100 c/s intervals in the frequency range 50 to 8000 c/s to the sound pressures similarly measured in a speculum coupling an acoustic source to the ear canal. Rather different functions were obtained for each of five conditions: (1) normal, (2) hair-line slit in the tympanic membrane, (3) rupture of tympanic membrane, (4) fluid behind tympanic membrane, and (5) bulla open. The variability in each of the categories is presented. Variability was greatest in the normal ears and least in the bulla open ears. A.

612.858.75

4259. Tonal monaural diplacusis. W. D. WARD. *J. Acoust. Soc. Amer.*, **27**, No. 2, 365-72 (March, 1955).

Two similar cases of tonal monaural diplacusis are described. When low-intensity sinusoids within a certain range are presented, several distinct tones are heard in addition to the tone presented. The effects are focused at 3610 c/s for one subject and at 3155 c/s for the other. Pitch-matching and probe-tone techniques show that the additional tones correspond to combination tones expected in a normal ear stimulated by two tones, one of which is fixed at one of the above frequencies. Hence some basic instability of the auditory mechanism at these frequencies is indicated for these observers. It is suggested that the defect lies in the "peaking" process of the cochlea, so that an adequate explanation of the phenomena may be of some importance to auditory theory. A.

612.858.76

4260. "Long-time" differential intensity sensitivity. I. POLLACK. Letter in *J. Acoust. Soc. Amer.*, **27**, No. 2, 380-1 (March, 1955).

Considers the differential intensity threshold made over "long" ($\frac{1}{2}$, 1, 3 day and longer periods) time intervals. Its purpose is to point out experimentally what is obvious from personal experience. When a given sound is repeatedly experienced with no variation, small changes in that sound can be detected even over long time intervals. A.

612.858.76 : 534.831

4261. Contribution to the study of auditory fatigue. C. LIGHTFOOT. *J. Acoust. Soc. Amer.*, **27**, No. 2, 356-64 (March, 1955).

Fatigue and other effects of 3 minutes of strong (105 db) acoustic stimulation were studied. Four combinations of fatiguing sound (white noise or 2kc/s tone) and test frequency (3 or 4kc/s) were each used twice for each of 24 subjects. Mean threshold recovery functions closely resembled many of the individual functions reported by Hirsh and Ward and confirmed the phenomenon they called "bounce"; however, many individual functions, like Hood's, were monotonic. Largest inter-subject and smallest intra-subject variability were associated with the noise/4000 combination. Subjects differed considerably with respect to general fatigability and recovery rate, and they tended to remain in the same rank order throughout the post-stimulatory period. There was a positive but low relationship between the fatigue a subject displayed under one condition and what he displayed after the same recovery time under another condition; the relationship was generally highest after the first 3 minutes following stimulation. Many individual recovery charts displayed a roughness indicative of a recurring disturbance of considerably shorter duration than the bounce effect. There was no obvious relationship between threshold shift and display of either roughness or bounce; nor could these latter two phenomena be entirely accounted for by tinnitus. A.

615.849.7

4262. Radiation therapy with radioactive cobalt-60. J. H. PANNELL. *Atomies [London]* **5**, No. 12, 329-32 (Dec., 1954).

As a source of γ -rays for the treatment of malignant tumours and certain hypertrophies, radium will probably be replaced, in future years, by artificially radioactive substances produced in nuclear reactors. A number of γ -emitting radioisotopes have been used therapeutically in recent years with results which indicate which of these substances are most likely to be adopted generally. A.

TECHNIQUE. MATERIALS 62/69

PHOTOGRAPHY 77

771.5

4263. The area law in granularity. Theoretical considerations. II. Syzygial measurement arithmetic

mean diffraction correction. R. DEBOT. *Bull. Soc. Roy. Sci. Liège*, **23**, No. 9-10, 308-21 (Sept.-Oct., 1954) In French.

For Pt I, see Abstr. 8819 (1954). Various problems arising in the measurement of granularity are

discussed. A diffraction correction is calculated for measurements made with a non-uniformly illuminated area. Corrections to be applied in syzygial measurements are also calculated, and the arithmetic mean of the fluctuations in the measured density is given.

P. ROTHWELL

771.53

4264. Study of the resolving power of photographic emulsions. R. MAUGE. *Onde élect.*, **34**, 1013–19 (Dec., 1954) In French.

An account of work first published in 1936. A test chart having line and dot patterns and symbols varying over a wide range of sizes was photographed and the legibility of the images determined by counting recognizable symbols for each size, time of development and length of exposure. For the emulsions used, and with an object of sufficient contrast, the maximum legibility occurs for an exposure corresponding to the maximum slope of the blackening curve. Resolving power is defined by the limits of image size giving 0 and 100% legibility, object contrast and exposure being optimal. S. T. HENDERSON

771.534.55

4265. Photographic granularity and graininess. VIII. A method of measuring granularity in terms of the scanning area giving a threshold luminance gradient. L. A. JONES, G. C. HIGGINS AND K. F. STULTZ. *J. Opt. Soc. Amer.*, **45**, No. 2, 107–12 (Feb., 1955).

For Pt VII, see Abstr. 5231 (1951). It is shown that, when a photographic image of uniform density is viewed under such conditions that graininess is just perceptible, the average spatial luminance gradient on the cones of the eye is a function of the density of the sample alone if the illuminance on the sample is held constant. This function, which bears a logarithmic relation to net density and is independent of the nature of the photographic image, is herein termed the *threshold gradient sensitivity function of the eye for graininess*. Granularity is defined in terms of the diameter of the scanning aperture that will produce this threshold gradient on the cones of the eye for the density of the sample in question. It is shown that granularity as thus expressed can be multiplied by a constant factor to give the same numerical value of threshold graininess that would be obtained by measuring the sample visually under standard conditions. A.

772

4266. Sensitizing absorption and photochemical reaction products in silver bromide during irradiation. G. SEIFERT AND O. STASIW. *Z. Phys.*, **140**, No. 1, 97–105 (1955) In German.

The changes in absorption in AgBr–Ag₂S at various low temps., both on keeping and after irradiation with light of 4358 Å, are shown, and the importance of ionic and electronic processes discussed in terms of interstitial silver ions, sulphur ions, and bromine ion vacancies. By irradiation at 153°K small absorption maxima due to photochemical reaction products are developed at 5500, 6400 and 7200 Å, whereas at 90°K long exposure gives only a small absorption at 6400 Å. The main absorption max. at 4900 Å, attributed to S ions, is seen only at 90°K, and is removed by irradiation. AgCl behaves differently by giving photochemical reaction products at 90°K.

S. T. HENDERSON

4267. On the theory of photographic process. K. P. SINHA AND A. B. BISWAS. Letter in *J. chem. Phys.*, **23**, No. 2, 404 (Feb., 1955).

Latent image formation in sulphur-sensitized emulsions may be due to the complex (Ag₂S)⁺ Br[–], which is assumed to form a cubic BaTiO₃ lattice which can trap electrons more effectively than AgBr. The complex may also produce trapping centres by dislocations. S. T. HENDERSON

778.3 : 778.6

4268. Recording the visible spectrum on color film. E. S. HODGE. Letter in *J. Opt. Soc. Amer.*, **45**, No. 1, 64 (Jan., 1955).

Details of working with 35 mm film are given. It was found impossible to overexpose.

S. T. HENDERSON

778.33

4269. Wet-process autoradiography modified for studying metals. G. C. TOWE, H. J. GOMBERG AND J. W. FREEMAN. *Nucleonics*, **13**, No. 1, 54–8 (Jan., 1955).

The preparation of metallographic specimens for wet-process autoradiographs is described. An autoradiograph of the cross-section of a 15 μ thick Pt foil plated on either side with active Ni indicated that a resolution of 10 μ was obtainable. Some results of studies with the process are very briefly outlined.

L. R. SHEPHERD

778.34

4270. On multiple scattering measurements in nuclear research emulsions. A. G. EKSPONG. *Ark. Fys.*, **9**, Paper 5, 49–75 (1954).

The sources of error in mass and energy determinations from measurements of scattering in nuclear emulsion tracks are discussed in detail and a semi-automatic recording attachment to the measuring microscope to facilitate these is described.

M. A. GRACE

778.34

4271. The study of heavy unstable particles using stripped emulsions. Introductory remarks. N. DALLAPORTA. *Nuovo Cimento Suppl.*, **12**, No. 2, 173–80 (1954).

778.34

4272. On the determination of the time regression [fading] and shrinkage coefficient of thick-layer photo-emulsions. I. M. GRAMENITSKIĬ AND M. I. PODGORETSKIĬ. Letter in *Zh. éksp. teor. Fiz.*, **27**, No. 3, 389–90 (1954) In Russian.

The shrinkage coefficient was measured after impregnation with an α-emitter. The fading was determined from observations on the 4- and 5-prong stars due to impregnation with RdTh. J. HUGHES

778.34

4273. A new method for the photometry of particle tracks in photographic emulsions. YU. P. MIRONENKO AND ZH. S. TAKIBAĖV. Letter in *Zh. éksp. teor. Fiz.*, **27**, No. 3, 390–2 (1954) In Russian.

The experimental arrangement is described, the method involving the use of photomultipliers. Graphs are given of typical results from proton and meson tracks. J. HUGHES

778.34
4274. On the construction of large nuclear emulsion block detectors. R. R. DANIEL, G. FRIEDMANN, D. LAL, Y. PAL AND B. PETERS. *Proc. Indian Acad. Sci. A*, **40**, No. 4, 151-7 (Oct., 1954).

Several hints on construction and processing are given. In particular a new alignment technique is described, using networks of α -active nylon threads placed between successive emulsion layers.

J. J. WILKINS

778.34
4275. Isothermal processing of thick nuclear emulsions. H. YAGODA. *Rev. sci. Instrum.*, **26**, No. 3, 263-6 (March, 1955).

A method for the processing of thick nuclear emulsions is outlined which develops the tracks of singly charged particles at the minimum of ionization without resort to a hot stage. The developing agent is introduced into the thick layer by means of a series of solutions varying in pH from 4.7 to 7.2 and of increasing reducing power. Uniform depth development is secured by allowing the last solution to diffuse out of the emulsion into water at 5°C. The processes of fixation and washing are designed to avoid resolution of surface silver grains, and to keep lateral swelling at a minimum. Turbidity resulting from residual silver iodide is reduced by means of a buffered thiourea solution. Thick unsupported emulsions can be restored to approximately their original size by leaching the electrolytes from the gelatin with a series of graded alcohols. The isothermal cold processing reduces distortion and facilitates the microscopic study of preparations up to 2 mm thickness by minimizing danger of over-development and production of excessive fog.

A.

778.34 : 539.18
4276. Photo-electric determination of the energy loss of fast heavy particles ($Z \geq 2$) in nuclear emulsions. N. NORLIND. *K. Fysiogr. Sällsk. Lund, Förhandl.*, **24**, Paper 12, 13 pp. (1954).

Shows that the determination of the energy loss of fast heavy particles in G-5 emulsions can be improved

by using the photoelectric method instead of δ -ray counting. This is true especially at an energy loss corresponding to min.-ionization particles with the charge $Z = 3, 4, 5, 6$.

A.

778.37
4277. Single exposure photography of a high speed event. K. R. TUSON. *Brit. J. appl. Phys.*, **6**, No. 3, 99 (March, 1955).

A method is described whereby conventional strobo-flash and photoflash equipment can be used to provide a series of photographs of a recurrent event which cannot be mechanically linked to trigger the flash. Photoelectric triggering capable of accurate visual control and adjustment is therefore provided and the method has been satisfactorily applied to a study of the formation and behaviour of bubbles rising from a submerged orifice.

A.

778.52
4278. The theory and design of rotating mirror cameras. H. EDELS AND D. WHITTAKER. *J. sci. Instrum.*, **32**, No. 3, 103-7 (March, 1955).

The fundamental parameters associated with rotating mirror cameras are defined and related to constants of the optical system. The effects of the mirror dimensions upon the camera properties are discussed in detail. The camera errors are defined and expressions are obtained for these errors which include the effects due to depth of field and possible defocusing of the image. The procedure for the design of a camera based upon an allowable error is developed.

A.

778.52
4279. A driving unit for a "time-lapse" ciné camera. A. F. HUGHES AND W. R. HUGHES. *J. sci. Instrum.*, **32**, No. 3, 107-8 (March, 1955).

A driving mechanism for a camera is described which is used in making speeded-up films of living biological material under a microscope. A positive intermittent drive is given to the camera, such that the film is moved on one frame and a single exposure made on each occasion. The intervals between exposures can be varied by a system of switches.

A.